

160 years of innovation theengineer.co.uk November 2016 | £3.70

O N N I

Fast track

The emerging tech firms driving automotive development

Insect inspiration

UK team develops flapping-wing military drone based on the dragonfly



Measuring up

NPL chief Peter Thompson on how measurement can help bridge the valley of death



Supply side

A job in the auto industry doesn't necessarily entail working for one of the big OEMs





The latest news, trends and case studies from the world of manufacturing technology



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

thisissue

news

- 04 Automotive Consortium will supply remote-handling system for ITER project
- **Electronics** Fast optical transistor 06 can alter metal oxide
- 08 Software Three-dimensional modelling using mobile-phone cameras

opinion

- **16 Viewpoint** Greg Clark
- Mailbox Your letters to the editor 18
- 20 Paul Jackson Attitudes to engineering
- Interview Peter Thompson 30
- 32 Scifi eye The planet Mars

features

- 22 Cover story Driverless cars are no longer just seen as futuristic
- 27 Feature Drones could help reshape the practice of urban warfare
- 34 Defence
- 53 **Automation**
- **Drives and motors** 57
- 60 Careers Automotive supply chain
- 65 **Archive**
- 66 Digest

advanced manufacturing

- **Machine tools** 41
- 42 Metrology
- Additive manufacturing 45
- Opinion 46

Your number-one website for engineering news, views, jobs and products theengineer.co.uk

ouropinion

Move with the times

he rapid pace of technological change in the automotive sector in recent years has surprised everyone: consumers, industry commentators, and - perhaps most of all carmakers themselves.

Take autonomous vehicles. A decade ago the prospect of self-driving cars was at best a fringe concept: an area of research with one foot in reality but the other firmly in the realms of science fiction.

Today, along with electric powertrain technology, autonomy is a cornerstone of the sector's plans for the future, with almost every major carmaker placing it at the

heart of their plans for the future.

In this issue's cover story (p22) we take a look at one of the key drivers behind this revolution - the irresistible influence of relatively new entrants to the automotive world: Tesla, Google and, more recently, ride-sharing pioneer Uber.

Unconstrained by traditional car industry methods of technology development and testing, and less risk-averse than the incumbents, these organisations have invested heavily in the autonomous dream. And carmakers, perhaps afraid of being left behind, have been swept along by this more aggressive approach.

Interestingly, one factor that almost certainly isn't driving this change is consumer demand. Whenever we cover the topic in this publication many readers admit that the prospect of ceding control to a robot leaves them cold.

"The prospect of ceding control to a robot leaves many readers cold"

The industry is clearly banking on this changing and, in an effort to win consumer confidence, is focusing its efforts on stressing the safety benefits of handing over control to a computer. As we report, Tesla has been particularly bullish in this regard: arguing that it would be morally wrong to let negative media reports or concerns over a slow-to-adapt legal system stand in the way of technology that it believes will save lives.

Whatever your view, there's no doubt that it's an exciting time to be joining the sector, with the rise of new concepts creating fresh opportunities for engineers (as illustrated in this issue's career feature, p60) and exciting commercial avenues for the more nimble members of the industry's supply chain. Our article on Coventry pod-car manufacturer RDM group (p38) is an interesting case in point.

Jon Excell Editor

jon.excell@centaurmedia.com

UK subscriptions £75 pa UK/£117 pa overseas. Order online at www.theengineer.co.uk/subscribe or by telephone on +44 (0207) 292 3705. All rights reserved. No part of this publication may be reproduced in any form without prior permission from the publisher

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



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 (4/125) 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) philipajison@centaurmedia.com Recruitment advertisement manager Ben Cogger (4187) ben.cogger@ 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

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



ROBOTICS

€100m removal of radioactive items

Consortium will supply remote-handling system for use in ITER project STUART NATHAN REPORTS

he largest contract for a nuclear fusionrelated robotic system has been awarded to a consortium comprising Airbus Safran Launchers, Cegelec CEM and Nuvia.

Worth around €100m (£89m) over seven years, the contract covers the development, testing and installation of a system for the remote handling of containers of radioactive equipment from the reactor vessel of the enormous experimental fusion reactor, ITER, currently under construction near Marseilles.

The system is called the Cask and Plug Remote Handling System (CPRHS). It is an essential part of the reactor's maintenance system and will be a challenging design because it must function in a very confined space.

The casks mentioned in the system's name are similar in size and shape to standard shipping containers; they are designed to contain components from inside the ITER tokamak, where exposure to the high-energy neutron flux produced by too radioactive for human contact. Items needing attention will be placed robotically inside the casks for transportation to a 'hot cell' within the ITER complex where they will be inspected, tested, maintained and, if necessary, scrapped.

The CPRHS will consist of 15 casks and, when full, the heaviest will weigh close to 100 tonnes. The transport system inside the complex will take the casks via a circuitous route around the outside of the toroidal vacuum vessel. including changes in level.

The CPRHS includes the remotehandling equipment for deployment in the reactor chamber itself.

Lead contractor on the project Airbus Safran Launchers was chosen for its experience of designing and building automated systems to work in space.

"Space is an extreme environment in which no human intervention or repair work is conceivable," said Christine Francillon, head of complex systems and infrastructure programmes. "We took our space know-how - developed on the Ariane

The CPRHS is an essential part of the reactor's maintenance system

nuclear fusion will render everything said sales director Pascal Champ. UK company Nuvia is the project management specialist in the consortium. The project is complex, it explained, including detailed design, procurement, manufacture, factory acceptance testing, installation, on-site commissioning, integration and testing.

Also part of VINCI Energy, the company has been involved in the UK nuclear sector for many years. "Contributing to world-leading science and research projects is central to Nuvia's strategy," said chief executive Keith Collett. "It is gratifying to be recognised for our proven capabilities as an international project management organisation, supported by our wealth of experience across

launcher and the fully automated ATV

space cargo - and adapted it for the remote-handling project of ITER."

Cegelec CEM, part of VINCI

equipment for the nuclear field and is

handling the mechanical engineering

"ITER offers our company a unique

opportunity to demonstrate its ability to

application in such a complex context,"

develop and build bespoke remote-

handling equipment for a nuclear

Energy, designs and deploys

aspects of the project.

multiple disciplines. Our mission now is to safely and successfully deliver to our client's expectations." Nuvia will be supported by the UK Atomic Energy Authority. UKAEA head of business development Martin Townsend said: "Partnerships

between fusion research laboratories and industry are essential to develop the technologies necessary for ITER's success."

Readmoreonline

Automotive

Industry 4.0 could move mass customisation into automotive mainstream

Aerospace

Strathclyde's 'silent lookout' wins European Satellite Navigation Competition

Civil & structural 'Sensing skin' spots cracks and harmful substances in structures

Defence & security Spinach plants modified to detect explosives

Electronics & communications Device for the blind uses computer vision and machine learning

Energy & environment Project promises CO₂ capture at \$30 per tonne

Medical & healthcare Wearable exoskeleton mimics human knee

Manufacturing

TU Wien team builds 3D-printed magnets with customised properties

Policy & business IP earnings: how earlystage tech innovators are profiting from licensing and sales

theengineer. co.uk





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.



Long life battery. Easily interchangeable.

Pressure generation station. For stand-alone operation.

www.gemeasurement.com

ELECTRONICS

A definite change in physical state

Fast optical transistor can alter metal oxide from insulator to conductor STUART NATHAN REPORTS



The team has been investigating the properties of very small antennae

team investigating the properties of very small antennae has produced a fast optical transistor capable of

changing the physical state of a metal oxide from insulator to conductor. The team is looking at

nanostructures that interact strongly with light; an area of interest because it could allow optical devices to be used for a wide variety of applications, for example, in computing and medicine. Such structures are smaller than the wavelength of visible light, yet allow light energy to be concentrated to a very high level.

Working with teams at Salford University and the University of the Basque Country in San Sebastian, the Southampton researchers used gold nanoantennae to achieve a phase transition in vanadium oxide. At room temperature, vanadium oxide is an insulator, but if heated above 68°C its structure changes and it conducts electricity; this makes it potentially useful in optical transistors, because light energy can be used to rate its temperature.

A team at Salford University that specialises in thin-film deposition fabricated a 50nm-thick film of vanadium oxide on a sheet of glass that had previously been coated with fluorine-doped tin oxide (this ensured that the vanadium oxide was very smooth, with only 5nm roughness). On top of this layer, the team fabricated gold nanoantennae using electron-beam lithography to deposit a 45nm-thick layer, the unwanted parts of which were removed with acetone to leave semi-cylindrical structures 80nm wide and with length varying between 160 and 360nm.

Back at Southampton, the samples were exposed to picosecond pulses from a Yb-fibre laser producing energy with a wavelength of 1,060nm. Although the temperature of the samples was well below the phase transition point, the areas directly below the antennae underwent phase transition and became conducting. This effect was very localised.

The researchers explain their work in a paper in the journal *Light, Science and Applications*. Lead author Prof Otto Muskens said: "The nanoantenna assists the phase transition of the vanadium dioxide by locally concentrating energy near the tips of the antennae. It is a lightning-rod effect. Antenna-assisted switching thus results in a large effect while requiring only a small amount of energy."

Calculations from San Sebastian showed that switching only required picojoules of energy. "If we are able to actively tune a nanoantenna using electrical or optical signal we could achieve transistor-type switches for light with nanometre-scale footprints for data communication," Muskens added. ©

AUTOMOTIVE

Take a closer look at the crankshafts

Problem of engine failures is identified by testing

ANDREW WADE REPORTS

Ricardo and Axiom have identified a crankshaft problem causing engine failures for a big car manufacturer. The unnamed OEM appointed

Ricardo to investigate why crankshafts

were failing across one of its engine families, and Ricardo brought in Axiom as consultants. Stockton-based Axiom sectioned the broken crankshafts to examine the machined radius profiles of the journals, which can be a factor

in the initiation of fatigue issues. "The crankshafts were sectioned so our experts could study the actual crack face. In some cases we will actually 'break open' a crack and examine it under a high-powered microscope; the peaks and troughs of the crack are like an open book to experts in failure analysis," said Axiom co-founder and metallurgist Dr Rene Hoyle. "Once the extent and type of failure was plotted it was a relatively simple matter to identify the cause, which in this case was due to metal fatigue."

Although the engines were already operating, the problem had not been identified during pre-production testing. It was discovered during Ricardo's endurance tests. Following extensive running, the crankshaft problem was revealed.

"No one wants to suffer a catastrophic engine failure, such as a snapped crankshaft, in the outside lane of the M1," said Hoyle.

"Manufacturers go to great lengths to make sure their latest designs are suitable for the intended application, but if things go wrong and cracking is found, they need to understand what is causing the problem." (

Newsinbrief

On the runway

Government ministers have approved a new runway at Heathrow Airport, a decision expected to create up to 77,000 jobs by 2030. The Department for Transport predicts economic benefits worth up to £61bn. Transport secretary Chris Grayling said: "After years of discussion and delay this government is taking decisive action to secure the UK's place in the global aviation market."

Claiming first place A Toyota Mirai powered by a hydrogen fuel cell has claimed first place at the inaugural Monte Carlo e-rally, an FIA event open only to zero-emissions vehicles. The Toyota successfully completed the 1,000km course ahead of 34 other crews from nine different countries. The Mirai was supported by a mobile hydrogen refuelling station over the five-day event.

Batteries of the future Scientists at Cambridge University are developing a new battery that has five times the energy density of lithium-ion counterparts. The lithium-sulphur battery has a nanostructured layer of zinc oxide wires on its cathode. The nanowires prevent degradation of performance by trapping polysulphides around the cathode and preventing them being lost into the electrolyte.

Low-emission goals

The Department for Transport has unveiled a strategy to encourage adoption of lowemissions vehicles, including increased access to charging points and hydrogen refuelling. The number of new ultra-lowemission vehicles registered has risen by 250 per cent in just two years, and secretary of state for transport Chris Grayling has set a goal for all new cars and vans to be zero emission by 2040.

For news and jobs theengineer. co.uk





GET SOLIDWORKS PREMIUM FOR THE PRICE OF STANDARD

Save 37%*

solidsolutions.co.uk/specialoffer 01926 333777

*Offer only valid on new license purchases with the corresponding Subscription Service according to the current SOLIDWORKS Price List. Offer valid until 16th December 2016 and cannot be combined with any other offer or discount. Offer not applicable to Education Licences. Other restrictions may apply.

SOFTWARE

All a matter of reconstruction

Three-dimensional modelling achieved by using mobile-phone cameras Helen KNIGHT REPORTS

arge spaces can be reconstructed with photo-like accuracy using the camera on a mobile phone, thanks to a three-dimensional modelling system

developed at Oxford University. The system, known as InfiniTAM, could allow a handheld camera to scan a complex environment and instantly build a 3D model. It could be used in virtual reality or augmented reality games such as Pokemon Go, or for industrial applications such as surveying buildings, processing plants or oil rigs.

Existing systems designed to carry out 3D reconstruction on mobile devices have tended to have poor accuracy, according to Dr Victor Prisacariu, principal investigator in the Active Vision Lab at Oxford University.

"This [system] opens up the ability to reconstruct large spaces very quickly on your mobile device," he said. "One possibility would be

"This system opens up the ability to reconstruct large spaces quickly"

Dr Victor Prisacariu, Oxford University to take one on to a submarine and map the ocean floor, for example."

For augmented reality games such as Pokemon Go, the system could allow the games to reconstruct and then interact with their local environment, for example, by enabling the virtual creatures to hide behind trees, Prisacariu said.

The InfiniTAM system is based on the use of a camera that produces depth information, such as the stereo cameras used on Apple's iPhone 7, or Microsoft's Kinect. The system then integrates this real-time depth information with tracking data on the position of the camera itself, allowing it to determine its own location and update the 3D map as it moves around.

To minimise the amount of processing power needed to produce the reconstruction, and thereby allow InfiniTAM to operate on a handheld device, the system only allocates memory to those surfaces that are currently visible in the scene before it, and disregards those elsewhere in the map. This decreases the complexity of the reconstruction task, said Prisacariu.

To determine its own location, the system uses the 3D map of the scene to constantly compare the reconstruction it has produced with the real-time scene from the camera itself. In this way it is able to compare what it calculates should be visible in the scene, to what is actually there, and can adjust its positioning information accordingly.®



The system could be used in virtual reality for industrial applications

AEROSPACE

Becoming an astronaut

Escape system under test on reusable vertical take-off, vertical landing spacecraft

Blue Origin's goal of creating an 'astronaut experience' for fee-paying members of the public has taken a step forward with the successful test of New Shepard's escape system.

New Shepard is Blue Origin's reusable vertical take-off, vertical landing spacecraft that consists of a pressurised capsule on top of a booster.

Launched from a site in Texas, New Shepard

performed an in-flight test of the capsule's escape system, which is designed to propel the crew to safety if a problem is detected with the booster.

Less than a minute into the mission and at 4,893m, the capsule separated and the escape motor fired, pushing the capsule away from the booster.

Reaching an apogee of 7,092m, the capsule then descended under parachutes.

After the capsule escape, the booster continued its ascent, reaching an apogee of 93,713m.

At just under eight minutes into the mission, the booster executed a controlled, vertical landing back at the Blue Origin's West Texas Launch Site, marking the completion of its fifth and final mission. **JF**

AUTOMOTIVE

Set the controls for a future of autonomy

Tesla will equip all its cars with self-drive technology

STUART NATHAN REPORTS

Tesla has announced that all of its future vehicles will be equipped with self-driving technology.

The company claims that autonomous capability will make Teslas safer than human-driven cars, will reduce the cost of transportation and "provide low-cost on-demand mobility". The system represents an updated version of Tesla's existing Autopilot driver assistance technology.

Tesla explained that all of its vehicles, including those currently produced in its Nevada factory and the new Model 3, will be equipped with "the hardware needed for full self-driving capability at a safety level substantially greater than that of a human driver".

This hardware will include eight surround cameras providing 360° vision around the car to a distance of 250m; 12 ultrasonic sensors designed to detect both hard and soft objects; a forward-facing radar with enhanced processing that the company claims can see through heavy rain, fog, dust and even the car in front; and a new on-board computer running a proprietary neural net to process the visual, sonar and radar data.

"Together, this system provides a view of the world that a driver alone cannot access, seeing in every direction simultaneously and on wavelengths that go far beyond the human senses," Tesla claimed.

Although Model X and Model S cars with this hardware installed are already available, Tesla said that the features enabled by the system are not yet activated.

Tesla will be equipping all of its cars





GET SOLIDWORKS PREMIUM FOR THE PRICE OF STANDARD

SAVE 37%*

Cadtek.com/SpecialOffer

01663 741405





*Offer only valid on new license purchases with the corresponding Subscription Service according to the current SOLIDWORKS Price List. Offer valid until 16th December 2016 and cannot be combined with any other offer or discount. Offer not applicable to Education Licences. Other restrictions may apply.

AUTOMOTIVE

Burning up the wax for hydrogen cars

Team discovers that hydrogen can be easily and instantly extracted from wax stuart NATHAN REPORTS

> he biggest obstacle to developing hydrogen-powered vehicles – whether the hydrogen is burned as a conventional fuel or

used in a fuel cell to generate electricity - is the lack of a storage method.

A team from Oxford University believes that it may have found a material to do the job. Working with researchers in Cambridge and Cardiff in the UK, and with colleagues at the King Abdulaziz City for Science and Technology (KACST) in Saudi Arabia, the team has discovered that hydrocarbon wax rapidly releases large amounts of hydrogen when activated with metal catalysts and microwaves.

Hydrocarbon waxes are derived from crude oil, or can be made in high purity as the end result of a gas-to-liquids process.

The Oxford team theorised that it should be possible to convert up to 14 per cent of the weight of a heavy hydrocarbon wax into hydrogen. The challenge, it explains in a paper in *Scientific Reports*, was to find a way to dehydrogenate a wax rapidly, reducing unwanted by-products.

The team used the transition metal ruthenium as a catalyst, with the metal in a nanoparticle form on a carbon support, mixed with paraffin wax. When this substance was placed in a microwave cavity and irradiated, the wax released about 7 per cent of its weight as hydrogen.

"Our discovery – that hydrogen can be easily and instantly extracted from wax, a benign material that can be manufactured from sustainable processes – is a major step forward," said one of the paper's co-authors, Dr Tiancun Xiao, a senior research fellow at Oxford University. "Wax will not catch fire or contaminate the environment. It is also safe for drivers and passengers."

"This is the future – transportation without CO₂ and hot air"

Prof Peter Edwards, KOPRC

Prof Peter Edwards, who leads the KACST-Oxford Petrochemical Research Centre (KOPRC), a KACST Centre of Excellence in Petrochemicals at Oxford University, said: "Instead of burning fossil fuels, leading to CO_2 , we use them to generate hydrogen, which, with fuel cells, produces electric power and pure water. This is the future – transportation without CO_2 and hot air." (

Hydrogen-powered vehicles need an effective storage method



SENSORS

All in real time

Proximity sensors could be a good fit for turbine blades in extreme environments

An Oxford University spin-out has received new investment to develop proximity sensors and fluid contamination systems for use in extreme environments.

IMechE made the investment into Proxisense through its £2m Stephenson Fund.

The proximity sensors are said to have uses in systems that monitor the health of turbine blades in real time, which can extend component lifetimes and reduce maintenance and downtime costs.

Co-investors Parkwalk, a London-based investment firm, said that Proxisense is targeting the

NUCLEAR

Working out the key to keeping plasma stable

Team works on 'stability map' for nuclear plasma stuart NATHAN REPORTS

Keeping a nuclear fusion plasma stable is probably the most important aspect of controlling these potential future energy sources.

In the type of reactor under the most intense investigation around the world, plasmas are heated to millions of degrees centigrade and induced to circulate at high speeds around doughnut-shaped reactor vessels.

But if the plasma becomes unstable, it can collide with the interior walls of the reactor, which reduces the plasma temperature – stopping the fusion reactions – and also damages the reactor walls.

Previous plasma physics theory held that making the plasma rotate would keep it stable. However, Jack Berkery and Steve Sabbagh of Columbia University, who work at the Princeton Plasma Physics Laboratory (PPPL) in California, have discovered that the situation is more complicated.

While some plasmas become unstable if they rotate too fast, others are stable at lower rotation speeds. The key is to keep the rotation and a property known as collisionality



The sensors monitor turbine blades

power and aerospace industries for these scenarios and is working with Alstom, Siemens and Rolls-Royce.

Contamination of critical fluid systems is a significant issue where transportation assets require fuel and lubrication fluids from remote sources. Proxisense's system can reportedly provide real-time, reliable monitoring of these fluids and reduce damage to components. **JF**



Plasmas are heated to extremes

within a favourable range.

Collisionality, which relates to the frequency with which particles bounce off each other, was thought to reduce stability as it rises, but this is not the case, according to Berkery and Sabbagh.

The researchers have developed a 'stability map' that allows a plasma to be monitored in real time.

The map plots collisionality against rotation, to a 1,000th of a second resolution, and determines how close it is to instability.

One such map, created in experiments at the National Spherical Torus Experiment at PPPL, shows that, over time, collisionality decreases and rotation increases, leading the plasmas to become less stable.

Control engineers on magnetic fusion reactors could use such maps to tune the behaviour of plasma, ensuring that it stays within a stable region where its power output is maximised.

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





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*

AEROSPACE

Assessing a crash **landing on Mars**

ESA investigates reasons behind the loss of the Schiaparelli lander STUART NATHAN REPORTS



ngineers from the European Space Agency (ESA) have been trying to determine why the lander Schiaparelli crashed into the

surface of Mars on 19 October, which, according to imaging from NASA, caused the lander to explode on impact.

Schiaparelli was intended to test the soft-landing systems that ESA plans to use for the ExoMars mission to deposit its robotic rover and science suite safely on the Mars surface in 2020. The rover will drill into the surface to look for chemicals that could indicate the presence of past life

The lander reached Mars with the Trace Gas Orbiter (TGO) satellite, and began its descent according to plan.

It was monitored by the Giant MetreWave Radio Telescope in India but shortly before it was due to touch ground, the telescope lost contact with Schiaparelli.

NASA's Mars Reconnaissance

The ExoMars team intends to replicate the failed landing using a hardware and software simulator

Orbiter returned images showing a large amount of disturbed ground at the landing site, leading the mission team to conclude the lander had been destroyed. However, it sent telemetry data back to the TGO throughout its descent, and flight engineers are now analysing this data to try to determine what went wrong.

According to Nature, the team has determined that four minutes and 41 seconds into the six-minute landing sequence, the lander's heat shield and

parachute both ejected. Its thrusters, which were supposed to fire for 30 seconds to decelerate the craft to a soft landing, engaged for three seconds. In theory, because the heat shield and parachute were gone, Schiaparelli's onboard computer thought it was already on the ground. The NASA images suggest it hit the ground at about 300km an hour, indicating that it had dropped uncontrolled for around 2km.

If, as the team suggests, this is a software problem then it should be possible to fix it for the ExoMars landing craft. The team intends to replicate the failed landing using a hardware and software simulator and Nature reports that project scientist Jorge Vago does not believe this will delay the next phase of ExoMars.

The TGO appears to be fully functional and will begin searching the Mars atmosphere for traces of methane that might have had a biological or geological source.



Schiaparelli was intended to test soft-landing systems

AUTOMOTIVE

Hitting the X-Trail

Nissan invests in Sunderland plant following assurances from UK government

Nissan will produce the next Qashqai and add production of the next X-Trail model at its Sunderland plant.

The decision follows UK government assurance that the Sunderland plant will remain competitive. Nissan will increase its investment in Sunderland, securing the jobs of more than 7,000 workers at the plant.

Commenting on the announcement, prime minister Theresa May said: "This is fantastic news for the UK. Nissan is at the heart of this country's strong automotive industry and so I welcome its decision to produce the Qashqai and a new model at its Sunderland plant."

Carlos Ghosn, chairman and CEO of Nissan, said: "The support and assurances of the UK government enabled us to decide that the next-generation Qashgai and X-Trail will be produced at Sunderland. I welcome British prime minister Theresa May's commitment to the automotive industry in Britain and to the development of an overall industrial strategy." JF

PROCESS

Steam crackers experience a gradual restart

Explosion and fire affects plant-supply pipelines STUART NATHAN REPORTS

BASF has restarted steam crackers at its Ludwigshafen headquarters following an explosion and fire on the pipelines that supply the plants.

The cause of the explosion, which is so far known to have killed four people and injured 25 others, is not yet fully established; however, it occurred near the plant's harbour on the pipelines that connect storage tanks where crude oil distillates are offloaded from tankers to the steam crackers.

Ludwigshafen is one of the world's largest chemical manufacturing sites, consisting of a very large number of plants producing commodity plastics, speciality chemicals, and many other chemical products.

It is very highly integrated, with heat from some chemical reactions being used to power other processes and by-products from some plants being reused as raw materials in others. The site operates two steam crackers, which convert naphtha - a substance distilled from crude oil - into the basic building blocks for plastics and other products.

As a result of the explosion, which occurred on 17 October 2016, the steam crackers were shut down, as well as all the plants that depend on their products. Particularly affected were the plants that produce materials whose production depends on ethylene and propylene. In total, 24 plants on the site were either closed or their production rates reduced.

The steam crackers are now ready to restart, according to BASF, but this will be done gradually because a new supply route for naphtha needs to be established that avoids the areas affected by the explosion and fire.



<u>CEOMEGA</u>

Your Fast Track Supplier for Process & Control Products

• 100,000 Products • Fast Delivery

• Technical Support • Easy Ordering

At OMEGA, we fast track your order to ensure your item arrives on time. Order multiple products to save time and money and complete your process control needs.

www.omega.co.uk











0800 488 488 sales@omega.co.uk

MATERIALS

How to turn carbon dioxide into plastic

Project wants partners to scale up onto an industrial stage stuart NATHAN REPORTS

Europe-wide project to investigate methods to convert carbon dioxide into plastics has

been launched at this year's K Fair in Düsseldorf.

Project EnCO2re currently involves a dozen research partners, including Imperial College London and Oxford University, in seven countries. The recent launch marks the point at which it is ready to work with industrial partners to scale up processes that are currently only in laboratories.

There are three main routes for CO_2 -to-chemical conversion, and the EnCO2re programme has active projects in two of them – catalysis and electrochemistry – and it plans to add projects in a third route, biological conversion, during 2017.

According to the programme partners, the CO_2 reuse market has the potential to grow by more than 20 times its current size, and could reach 3.7 billion tonnes per year: equivalent to around a 10th of global emissions.

Ted Grozier, programme manager, said: "While easy to point out the environmental problems of plastics, the reality is our society depends on these materials in critical sectors such as healthcare, insulation, and in making vehicles that are lighter and use less fuel. But we need to work out how to make these materials without using fossil fuels."

The EnCO2re programme, he added, aims not only to close the loop in the industrial carbon cycle and transform CO₂ from a hazardous waste product into a feedstock, but also to make such technology a pillar of European industrial competitiveness.

The programme is led by Climate-KIC, which is an EU-supported public-private partnership addressing climate change, and by polymer

"We need to work out how to make these materials without fossil fuels"

Ted Grozier, Project EnCO2re

producer Covestro (formerly Bayer MaterialScience). Research partners include Chalmers University of Technology, and the universities of Copenhagen, Oxford, Berlin, and Delft.

"Through the EnCO2re programme, Climate-KIC is bringing together top research institutes with industrial partners," said Sira Saccani, director of sustainable production systems at Climate-KIC. •

The EnCO2re programme aims to transform the status of CO2



COMMUNICATION

Things are hotting up

Battery overheating leads to Samsung pulling device out of production

Samsung has ceased production of its Galaxy Note 7 following a spate of incidents that saw the device's battery overheat and cause damage to people and property.

The company has told those with an original Galaxy Note 7 or replacement Galaxy Note 7 to power down and stop usage.

Samsung unveiled the device on 2 August 2016 but by 1 September the company was offering consumers replacement devices or refunds following 35 incidents attributed to the smartphone's non-removable li-ion 3500mAh battery.

NUCLEAR FUSION

Greater control of plasma as it is warmed up Team tackles problems with beam injection

STUART NATHAN REPORTS

Researchers have devised a method for achieving greater control over the behaviour of plasma as it heats up inside a magnetic-confinement fusion device.

The team, which works on the DIII-D tokamak at General Atomics in San Diego, has been tackling difficulties with the device's neutral beam-injection system.

A tokamak is a toroidal vacuum vessel surrounded by electromagnets



The team at General Atomics, San Diego



Samsung's co-CEO Dr Kwon Oh-Hyun

On 15 September 2016, the US Consumer Product Safety Commission reported that Samsung had received 92 reports of the device's batteries overheating in the US, including 26 reports of burns and 55 reports of property damage.

Despite Samsung's efforts to redress the issue, replacement handsets were reportedly malfunctioning too. **JF**

that keep the charged hydrogen plasma confined away from its walls while it is heated and accelerated around the torus to encourage its constituent particles to undergo nuclear fusion, releasing energy.

Neutral beams heat the plasma by injecting uncharged particles into the plasma at high speed. They transfer energy to the plasma particles through collisions, and also add momentum and torque to the spinning plasma.

Neutral field injection works by accelerating positively charged ions through a 90,000V electric field and sending them into a chamber of dense gas, where they pick up electrons and lose their positive charge.

Injecting these fast particles into the plasma can cause or amplify electromagnetic waves that kick the particles straight out of the plasma and into the tokamak walls, causing damage and losing the energy that the particle was supposed to transfer to the plasma. The General Atomics team has devised a method for tuning the

accelerating field so that the velocity of the neutral particles as they enter the plasma differs.

This responds to changes in the behaviour of electromagnetic waves in the plasma as it heats up, which, in turn, changes the way that neutral particles interact with it.

The new system varies the velocity of the neutral particles to minimise their interaction with the electromagnetic waves.



100

We help move man's **most marvellous machines**

Open. Push. Swing. Twist. Lift. Close. We're ideas makers. Creators of motion. Applying our imagination to help you keep your machines moving, in everything from industrial automation to rail. Working with you, we help render your vision real. All the time keeping our eyes on swift service and smart support.

Actuators. Valves. Air Preparation. Fittings.

Just imagine what else we could do for you... Visit: www.mostmarvellousmachines.com



viewpoint | greg clark



Britain is now due for an upgrade

Building on the UK's proven industrial strengths means also recognising some significant weaknesses, and acting upon them

n my view, we have had enough drama in British politics over the last year – I want us to recover our reputation for stability as a business environment.

Building upon proven strengths is a cornerstone of good strategy. This country has no shortage of them.

For a start, a powerful record on science and innovation; only the US has more of the world's top universities, Nobel prizes and registered patents.

We excel at the cutting edge of industry. Our motor industry has the most efficient plants in the world. A quarter of the satellites launched into orbit today are made in Stevenage.

We need to burnish these strengths.

We must provide the research funding to keep us out in front. We must ensure that land and supporting

"Britain can boast the richest area in northern Europe. But we also have nine of the 10 poorest"

Greg Clark

services are available not just to major employers but also to the increasingly integrated supply chain of smaller, specialist firms.

And we must set the technical and legal standards that create long-term confidence in Britain as a place to do business.

Of course, a modern industrial strategy is as much about potential as it is about existing strength. We must never be the protector of incumbency but instead be constantly looking to create conditions to be open to new competitors and indeed to new industries that may not exist anywhere today but that will shape our lives in the future.

In my view any successful industrial strategy has to be local. Governments are fond of quoting national figures of economic growth, of productivity, of employment. But the truth is economic growth does not exist in the abstract. It happens in particular places when a business is set up, or takes on more people, or expands its production. And the places in which you do business are a big part of determining how well you can do.

Yet for too long, government policy has treated all places as if they were identical. It seems to me that helping Cornwall make the best of its future is as vital to a comprehensive national success as helping Birmingham – but what is needed in each place is different, and our strategy must reflect that.

> Many of the policies and decisions that form our industrial strategy will not be about particular industries or sectors, but will be cross-cutting.

For us to succeed in the future we need to have the right infrastructure – roads, rail, broadband and mobile – that can connect businesses to their workforce.

The UK's motor industry has some of the most efficient plants in the world We need to have a rising generation of young people who are better educated than our competitors – and their predecessors – but also better trained.

In the debate about education we must make sure that vocational education plays a much more prominent role in our country than it has for many years now; and that employers have a decisive role in making sure that skills training is meeting the needs they have to fulfil their order books.

We need a tax system that clearly and reliably encourages entrepreneurship and innovation. And a modern system of corporate governance that builds widespread confidence in business.

For all of the astonishing economic progress we've made in this country, it is visibly uneven.

Britain can boast the richest area in northern Europe – central London. But we also have nine of the 10 poorest. We have some of the most productive businesses in the world but also a disproportionate number of low productivity businesses. We have people who are the most capable and best trained on the planet. But too many leave school or college without the education and training needed to hold down a job productive enough to support themselves and their family.

We have new infrastructure such as Crossrail about to open, but we have roads that are bottlenecked, trains overcrowded and broadband that is simply unacceptable in 2016. We have low-carbon energy systems that lead the world, but also the failure of successive governments to replace the power stations reaching the end of their lives.

This is no time to lower our sights or our standards. This country will never win a race to the bottom. Looking ahead, it is clear that the only viable path is in the opposite direction. I believe that it is time for our country to have an upgrade.

An upgrade in our infrastructure. An upgrade in our education and training system. An upgrade in the development and regeneration of those of our towns and cities that have fallen behind the rest of the country. And an upgrade in our standards of corporate governance and in the relationship that government has with businesses of all shapes and sizes.

Edited extracts of a recent speech given by Greg Clark, secretary of state for business, energy and industrial strategy, to the Institute of Directors annual conference 2016



Keep your mind on the job

When downtime isn't an option you can count on us to deliver your parts exactly when you need them.

And with a variety of dependable delivery options available you can keep your mind on the job, not the clock.



Discover more at



uk.rs-online.com

Mailbox

Thehottopic

The promised land

The decision to give the go-ahead for a new runway at Heathrow sparked a heated debate

Would another runway be required if Heathrow gave up its desire to remain a major hub airport? I find on the Heathrow website that 32 per cent of passengers in 2015 were just transferring between flights to and from outside of the UK. If this hub traffic was taken by other more suitable airports within Europe, then surely Heathrow could concentrate on domestic traffic only? I imagine this would result in a significant loss to Heathrow in terms of landing fees, but that should be measured against the costs of a third runway and the local disruption building it will cause. **Chris**

Are we not burdening our other creaking transport systems too much by forcing anyone who wants to travel to go to a south east that cannot cope with the transport requirements it already has? It looks as if the most expensive option possible has been chosen to maximise spend in the south east once again. **Mike West**

If unit emissions reduce by 1 per cent per year but passenger kilometres per year grow by 4 per cent (as predicted), then aviation's impact on climate change will inexorably grow. It is entirely unreasonable for anyone to argue that one sector of the economy should be allowed to increase its emissions when every other sector is expected to reduce both its carbon intensity and its total emissions. Unless the aviation industry accepts it must reduce flying, it has no chance of ensuring its emissions in 2050 are the same as in 2005. **Robert Palgrave**

You can reasonably argue that more airport capacity is needed around London. But Heathrow is just in the wrong place – which explains the high cost of £18bn – which still doesn't compensate the people of London. New runways at Gatwick and Luton would be much cheaper and more useful. **Alex** What London and the south east need is a new 'Heathrow' possibly located north to north west of London. The current site is way past its sell-by date. We need to plan for where we are going to be in 50 years, with outline planning for six to eight runways, and lose the 'tomorrow mentality' that they are working to now. Also, if HS2 was done properly we could dispense with most domestic flights. It would be quicker, as you waste at least 90 minutes getting on and off, checking in and collecting baggage. **Paul**

Why not build an extra runway at Heathrow and Gatwick? This stops all argument, future-proofs the south east and London, and allows the rest of the country to focus on its own development plans without the background noise. **Steve**

The short-term solution should be to do nothing at all with any of the London airports, and to make an immediate start on one or more airports and associated infrastructure in safe areas that can serve London and the rest of the UK. That would lead to the progressive reduction in air traffic over London and the south east, a reduction in the risk of disaster, plus all the obvious benefits to the folk living in London. This is nothing more than joined-up thinking. It is sad to think the only way this will happen is if, in the next year, while talks waffle on over the third Heathrow runway, two large passenger aircraft collide over central London, killing 500 on board, and 10,000 on the ground. Even then an inquiry would take 10 years to report. **Alick Nicholson**



Inyouropinion

Promises, promises

Nissan's decision to increase investment at its Sunderland plant prompted much speculation

The news is, of course, very, very welcome. Quite how much the government should be patting itself on the back or not I am unsure. What I am sure of is that every government around the globe – big, small, from the tyrannical to the most moderate – will always be 'encouraging' foreign investment. It is one factor in how the world of big business and government works. From oil to defence, from pharmaceutical to automotive, and any other sector you can name, there have been, in conjunction with just about every government, a collection of greasy palms and back-room deals. Do you know what? Don't knock it. It is a form of corruption but the world is a corrupt place – get used to it.

Stephen Rose

The government shouldn't ensure company profits by giving subsidies to companies. If subsidies must be given they should go to people who have difficulties in fending for themselves, such as the sick, the elderly, children and students. It is difficult to understand why those on the minimum wage should finance big companies with their tax. **Ralph**

Anyone who believes tariffs will be placed on UK-manufactured cars that go in to the EU must have forgotten how many cars and car components are sold into the UK from Germany (the country that appears to be running the EU). I am sure we would charge them the same tariff they charge us. **Iain** Any boost to UK manufacturing output has got to be good for us all in the long run. As the EU is a net car exporter to UK, it would be unlikely to threaten a tariff war on car imports and exports, as it would have more to lose than we would from any consequential fall in international car trade. Looking further ahead, it isn't a matter of if we start to manufacture plug-in electric cars with range extenders, it's a matter of when it will happen. Nissan has pioneered electric cars with its Leaf – so let's now encourage it to build a small inexpensive plug-in for the UK market. **Norm Williams**

I can't wait to find out what was promised to Nissan by the UK government. Cloud-cuckoo land comes to mind. As a so-called 'remainer', I still can't get over the shock of hearing the Sunderland vote come in on the morning of 24 June and I refuse to 'get over it' as one is constantly urged to do. Whatever promises have been made to Nissan must be made



Thesecretengineer

Our anonymous blogger reflects on the issues surrounding a 'team mentality'



A recent conversation with a colleague surprised me because he effusively congratulated me on my personal success with a project, when we both knew that he had helped me out with it. The responsibility for a project always has to be clearly defined and accepted by the person who takes the lead but, as far as I'm concerned, any success should reflect on all those involved.

Without wishing to appear woefully egocentric, undoubtedly I had driven us to the point where a resolution to a critical problem had been found but I was supported by him and a number of other colleagues in getting there. I summed up my view with a mumbled "We fail together and we succeed together."

This was no broad largesse, both he and I knew the extent of our respective inputs. However, it was important to me to acknowledge that there was a team effort. Perhaps more importantly, the MD of Sleepy Hollow Electronics has also been aware of who is responsible for what's gone on – not through any particular effort but because he keeps his finger on the pulse.

This may beg the question that if all I was doing was reinforcing common knowledge, what

is the value in it? While I remain suspicious of structured 'team-building' exercises, I fully believe that good working relationships are founded on actively deploying people skills – and founder on personal disinterest.

Equally important, this should be a hand that is underplayed rather than overplayed. It is far too easy to either lose the feeling of sincerity or to gain a feeling of any appreciation just being the result of cynically applied strategy.

What it doesn't mean is being careful of what you say to the nth degree. Again, such an approach brings the veneer of consideration-byrote. 'Banter' is a dreadful word used far too often these days to excuse boorish behaviour but when done properly can help release pressures and draw colleagues closer together.

The fact that my colleague in this case seemed so willing to emphasise my part in the success gave me cause to look back over my career and try to recall how similar situations had been handled in the past. I have to say that on the whole those I have worked for at an immediate level above me seemed to fall in line with my approach. Those at levels above them, however, seem entirely oblivious to the advantages such an approach can bring.

In fact, I have a feeling of only being engaged in conversation when progress was to be checked, or a problem was looming. I wonder if I would have felt more reassured if my experience of my superiors had been more balanced?

Likewise I think getting the best from a team lies in taking the time to find the balance between wielding the carrot and the stick. Perhaps that's exactly why I've never risen to the very top.

public and must be extended to every UK company and enterprise, however big or small. Jamie Taylor

Nissan made a commitment to production in the UK a long time ago and the potential cost of moving production away would be significant. It is happy that the government is capable of achieving a good deal for the UK and the best way to support that end is to re-state its commitment to investment here. Well done, Nissan, let's have more of the same, please.

Phil

It's hard to believe that a simple letter made the difference! Nissan will either have other reasons or there is a sleight of hand going on. **Brian**

I find it hard to believe that Mr Ghosn made an investment decision for Nissan based on a 'gentleman's handshake' – this is a man who turned round Nissan globally from a basket case. He is now CEO of Renault and has just taken over the automotive part of Mitsubishi. It's not hard to think that BMW, Honda and Toyota will be watching with interest. Although JLR is mired in an internecine fight back at Tata HQ, it will still be grateful for any handouts – whether for car production or steel. Goodness only knows whether the government's current largesse will extend to tier-one and tier-two suppliers. **Paul**

Join the debate theengineer. co.uk



FAULHABER CR

More bite for high power applications

3890...CR DC-Micromotors series

- Enormous continuous torque up to 224
 mNm, considerably higher in short-time
 operation
- Various voltage types from 18 to 48 V
- Optimally adapted for combination with FAULHABER precision gearheads and encoders



Distributed exclusively in the UK by

EMS www.ems-limited.co.uk

WE CREATE MOTION

column | paul jackson



Pipeline of the future

Public attitudes to engineering are starting to change after a number of high-profile events

"Through our initiatives we reached over 400,000 young people and 48 per cent of all UK secondary schools last year"

Paul Jackson

am writing this on the eve of the 2016 Tomorrow's Engineers Week (7-11 November). It's been great to hear about all the fantastic activities taking place across the UK throughout the week – companies and organisations such as Thames Tideway, Richer Education, IET, ICE and WISE have all helped shine a spotlight on engineering careers in a way that many young people, particularly girls, may never have considered before.

To mark the week, we've worked with visitor attractions nationwide such as Madame Tussauds, London Zoo, the Clifton Suspension Bridge and the National Space Centre to develop worksheets showing engineering in unusual places and highlighting how it plays its part in their everyday work. Visitors are able to find out that the roof of the London Zoo Tiger Territory is made of a superlightweight stainless-steel mesh and that Apollo's fuel cells can create water for the crew to drink, as well as generating electricity.

Leading up to Tomorrow's Engineers Week, we were delighted to once again bring a slice of The Big Bang UK Young Scientists & Engineers Fair to the House of Commons at the annual Big Bang @ Parliament event, hosted together with the Parliamentary and Scientific Committee.

It was good to see the chairs of the education and science and technology select committees there together with a host of politicians, policy-makers and companies, including BAE Systems and JCB, discussing the importance of getting young people into STEM and developing the right skills for future economic health. We also welcomed some of this year's young Big Bang Competition finalists to showcase their impressive projects, demonstrating just how talented the UK's future scientists and engineers are. Hearing from competition alumni Sarah Sobka, now a second-year medical student; and Kia and Sky Ballantyne, whose Crikey Bikey product has gone from strength to strength, showed just what an impactful and transformative

opportunity The Big Bang provides. This month also sees the third

anniversary of the Perkins Review, which looked at the need to equip people with the right STEM skills in order to compete in the global race. The report kicked off lots of different work streams – focusing not just on sending out leaflets, but really involving people. Through EngineeringUK's initiatives together we reached over 400,000 young people and 48 per cent of all UK secondary schools last year. The young people that have taken part in Big Bang and Tomorrow's Engineers agree that a 'career in engineering is desirable' to a much

The profile for engineering careers is getting stronger due to them being seen as a more desirable outcome



larger extent than the national average, showing that the profile for engineering careers is getting stronger.

Public attitudes to engineering really have changed dramatically over the past five years, which is demonstrated clearly by a new EngineeringUK survey revealing that 65 per cent of the UK population are able to name which engineering developments in the last 50 years have had the most impact on their lives. Unsurprisingly, the internet came out top, with developments in computers following closely after. This is a massive improvement since 2010, when the same question could only be answered by 38 per cent.

While Tomorrow's Engineers Week is a single point in the calendar, Tomorrow's Engineers takes place all year round; please get in touch if you would like to help build the talent pipeline of the future.®

Paul Jackson, chief executive, EngineeringUK



A rare opportunity

...to engage with Decommissioning Industry Leaders across all sectors TotalDECOM is a Unique One of a Kind Conference & Exhibition that brings together all industries in the decommissioning sector under one roof, to learn, connect and do business. Our 2017 Event will feature Specialist Engineering Conferences, Workshops & Seminars:-

- Sensing and imaging
- Monitoring & Maintenance
- Robotics
- ROV / UAV Inspection
- Modelling & Visualisations
- Automation & Control Systems
- Monitoring & Maintenance
- Support for Innovation
- Skills development

Come to our cross sector event and join the Nuclear, Renewables, Oil & Gas, Defence & Process industries and take your skills & expertise into new & exciting areas.

Premier Delegate Package & Free Visitor Open Day Tickets

Call 01229 400226 email 2017@totaldecom.co.uk totaldecom.co.uk

Agents of automotive change

Relative newcomers to the car industry are driving unexpectedly rapid technological change in a onceconservative sector. Helen Knight reports



small, two-seater 'pod' travelling at speeds of up to 15 miles per hour around central Milton Keynes may not sound like the future of transportation.

But the electric pods, which undertook their first journey around the town's public streets in October, are controlled not by a driver but by software fed with data from cameras and Lidar (light, imaging, detection and radiation) systems.

The LUTZ (Low-carbon Urban Transport Zone) Pathfinder vehicles, built as part of a project led by the Transport Systems Catapult (and examined

on p38), is just one example of how quickly things are changing in the car industry. Only a few years ago, technologies such as driverless cars, vehicle-to-vehicle connectivity and electric propulsion were seen as futuristic, fringe concepts.

However, Ford, BMW and Volvo have all now announced plans to bring out autonomous models by 2021, while GM has launched the all-electric Chevy Bolt, with a range of 238 miles on a fully charged battery.

Indeed, GM executives said that they expect vehicles to change more in the next five years than they have in the previous 50.

Much of this shift in gear has been driven by newcomers to the automotive industry, such as technology giants Google, Microsoft and Apple, electric vehicle specialist Tesla, and car-sharing firms Uber and Lyft.

In October, for example, Google revealed that its self-driving cars have clocked up two million miles of driving experience on public roads. Google has almost 60 self-driving cars across four US states, which learn more about the roads as they clock up each mile.

Meanwhile, rumours persist that Apple is developing its own autonomous electric car, under a project codenamed Titan.

Technology firms recognised early how important software was becoming to vehicles, according to Karl Brauer, senior analyst at US-based transportation research firm Kelley Blue Book. And their growing interest in the future of automotive technology helped encourage car makers to begin pushing ahead with their own plans, he said.

"Car makers have recognised, certainly in the last year if not in the last two to three, that they have to play a role, or they risk becoming obsolete."

One company that has perhaps done more than most to push the industry forward is Tesla. In October, the company announced that all of its future vehicles, including those currently being built and its upcoming and much-heralded affordable saloon, the Model 3, will be equipped with self-driving technology.

The system, an updated version of its existing Autopilot driver assist technology, will incorporate data from eight cameras, designed to provide a 360° view around the vehicle. It will also be equipped with 12 ultrasonic sensors and a radar system designed to see through fog, heavy rain, and even the car in front.

But before the new system is activated, Tesla said it first plans to calibrate the technology using real-world driving data from its fleet of cars, meaning vehicles with the new hardware will temporarily lack features such as automatic emergency braking and collision warning. Once the features have been validated, they will be enabled via the company's over-the-air software updates.

As the technology matures, all Tesla vehicles will have the hardware necessary

01 Volvo is one of many OEMs to embrace an autonomous future

02 Ford plans a fully autonomous vehicle by 2021

03/04/05

Ride-sharing firm Uber has had a profound impact to be fully self-driving, with "fail-operational capability", according to a Tesla spokesperson.

"This means that any given system in the car could break and your car will still drive itself safely," the spokesperson said. "Although it is important to emphasise that refinement and validation of the software will take much longer than putting in place the cameras, radar, sonar and computing hardware."

The company plans to begin production of its US\$35,000 Model 3, which will have a range of over 200 miles on a single charge, in 2017, ultimately ramping up to build 500,000 cars per year.

As part of the next stage of its "masterplan", Tesla is also developing autonomous heavy-duty trucks and high passenger-density urban transport.

Another clear indication of how information and communications technology (ICT) is changing the way cars operate lies in Tesla's over-the-air software updates, which allow the company to reprogram the vehicles and add new features, or to fix bugs in the system. "While traditional cars have static features, a Tesla is more akin to a smartphone, adding new functionality and enhancements throughout





the life of the car," the company's spokesperson said.

Newcomers such as Tesla, with a background in Silicon Valley, are not necessarily constrained by conventional car industry methods of technology development and testing. This can be seen in the way Tesla is testing its Autopilot system in what it calls a "public beta".

The software has been installed in all of Tesla's 70,000 cars since October 2014, alongside a warning that drivers remain in charge of the vehicle.

But many in the car industry feel that this warning is not clear enough for consumers, reflecting a significant cultural difference between the two sectors, said Dr Paul Nieuwenhuis, co-director of the Centre for Automotive Industry Research and Electric Vehicle Centre of Excellence at Cardiff University.

Concerns were raised earlier this year when the driver of a Model S in autopilot mode was killed when the car's sensors failed to distinguish a truck and trailer crossing the highway.

"It is felt by some that [Tesla] is pushing its autopilot too far and too fast, whereas the car industry would be more cautious with that sort of thing, because they know the safety issues, the litigation problems, and the recall problems," Nieuwenhuis said. "These are all less of a problem in the ICT sector, where if something doesn't work the first time you just fix it, and then it does."

Tesla counters that, when used correctly, the software is already significantly safer than a person driving by themselves, and it would therefore be "morally reprehensible" to delay its release for fear of bad press or legal liability.

"Car makers have recognised they have a role to play – otherwise they risk becoming obsolete"

Karl Brauer, Kelley Blue Book

Another company pushing ahead with autonomous vehicle technology is ride-sharing company Uber, which has been investing heavily in self-drive technology in recent years. In 2014 the company began recruiting engineers from Carnegie Mellon University's robotics department, in order to set up its own Advanced Technologies Center (ATC) in Pittsburgh.

In August the company began trials of its fleet of self-driving taxis in the city, in which customers are being randomly assigned one of its modified Volvo XC90 SUVs, with a safety driver supervising the journey.

The cars are equipped with a top-mounted Lidar to provide a 360°, three-dimensional scan of the environment around them, a forward-facing camera array to watch out for braking vehicles or pedestrians ahead, side and rear-facing stereo camera pairs, 360° radar coverage, and GPS positioning.

"Self-driving technology holds tremendous potential to improve road safety," the company said. "Today, 1.3 million people around the world die in car accidents every year, and 94 per cent of those involve human error." Uber also recently signed an agreement with Volvo to jointly develop new base vehicles able to incorporate >> >> self-driving technologies, up to and including fully autonomous cars.

The base vehicles will be manufactured by Volvo and then purchased by Uber, with both companies using the same cars for their own autonomous driving technologies.

The US\$300m project between a traditional car maker and a Silicon Valley-based technology firm is a sign of how the industry is adapting, said Brauer.

"There is a sense that you could build the technology yourself, or you could partner with or buy up another company that has already built it, which is quicker, and ensures that you get the expertise in-house that you need," he said.

One company that has been busy doing just that is GM, which has invested US\$500m in ride-sharing company Lyft, and in March bought self-driving car technology firm Cruise Automation for US\$600m.

Similarly, Ford, which recently announced plans to build a fully autonomous vehicle without a steering wheel or pedals for the ride-sharing market by 2021, has been expanding its technical expertise through investments in start-up companies.

The company recently invested in Velodyne, which produces Lidar sensors, for example, and acquired Israeli firm SAIPS, which makes computer vision and machinelearning software. It has also invested in 3D-mapping company Civil Maps, and has a licensing agreement with machine-vision developer Nirenberg Neuroscience.

Meanwhile, Renault-Nissan announced in September that it had signed an agreement with Microsoft to develop connected car technologies, based on the software giant's Azure cloud system.

The new services will include advanced navigation systems, predictive maintenance and remote monitoring of the vehicle, as well as communication with the outside world, and over-the-air software updates.

"An autonomous car has to be a connected car, since autonomous driving technology requires close to real-time updates of the road conditions to anticipate events or road changes," said a spokesperson for Renault-Nissan.

Renault-Nissan is aiming to develop the connectivity systems needed to support the launch of more than 10 vehicles with autonomous driving technology by 2020, as well as services to allow people to make better use of their "newly found in-car free time".

The plan will follow a step-by-step



06/07/08 Tesla recentlv

announced that all of its vehicles will be equipped with the hardware required for self-driving approach, with each step increasing the level of autonomy in the vehicles. In August, for example, the car makers launched single-lane control, giving drivers the choice of manually operating the vehicle or handing control over to on-board systems in certain situations.

The first such system, launched by Nissan as ProPILOT in August, allows cars to assist drivers steering, braking, and accelerating automatically in a single lane on motorways. The new Nissan Qashqai, which will be launched in Europe in 2017, will be equipped with ProPILOT technology.

In 2018, Renault-Nissan plans to launch a multiple-lane control application, which will autonomously negotiate hazards and change lanes during motorway driving. This will be followed in 2020 by intersection autonomy, which will navigate through city intersections without any driver intervention.

Collaboration across the industries will be crucial, as self-driving cars will need a single, standardised way of communicating with their environment in order to operate safely.

To this end, in April, Ford, Google, Uber, Lyft, and Volvo launched the Self-Driving Coalition for Safer Streets, a lobbying group designed to promote autonomous driving.

Autonomous cars will not only need to communicate with each other, but also with traffic lights and intersections, for example. And in constantly communicating with their environment in this way, they will generate a lot of data that is likely to be very valuable to companies.

Just who owns this data – the technology firm or the car maker – is likely to be a matter for considerable debate, said Brauer.





"We will probably see some push and pull about who controls the data, who owns it and how it is used, but that is one of the hurdles they will have to get over," he added.

Ford, for example, has said that a driver's data should remain just that – the driver's – and should not be shared or sold for other purposes, said Brauer. This laudable stance may explain why a much anticipated alliance between the car maker and Google has so far failed to materialise.

The cultural differences between car makers and technology firms, including the latter's greater apparent eagerness to test out software on the roads, could create the impression that the newcomers are pushing ahead in the race to develop autonomous, electric vehicles.

But that may not ultimately prove to be the case, said Brauer. "As difficult as it is to come up with all of the programming, software and sensors that it takes to build an autonomous car, that is still less difficult than coming up with a supplier base, an assembly system to produce the vehicles, and a retail network to sell and re-sell them," he said. "That is where the automotive manufacturers have an advantage."

Whoever wins the race to produce the first fully autonomous electric vehicle, however, the input of fresh ideas that the technology sector is bringing to cars looks set to transform the automotive industry. (9)

"An autonomous car has to be a connected car, since autonomous driving needs real-time updates"

Renault-Nissan



Pushing Performance

HARTING Automotive Providing the complete solution for the automotive production line.



Increased efficiency of the automotive production line, with the complete solution from a single source:

- Production line track and trace with RFID for increased efficiency
- Complete plant-wide Unmanaged Ethernet communications
- On-metal RFID tags for body and chassis tracking
- Full range of industrial connectivity across the production line
- MICA Industrial Computer offers an open network with customisation for application requirements

For more information phone +44 (0) 1604 827500 or e-mail gb@HARTING.com



VERSATILE MODULAR CONNECTOR SOLUTIONS

ODU MAC – our versatile modular connector solution enables signal, current, data rates, liquid, air and fiber optic transfer.

COMPLETE SYSTEM SOLUTIONS

ODU provides pre-assembled component solutions. The high level of expertise in development and manufacturing combined with our state-of-the art manufacturing facilities from Europe, China and USA enable us to offer to our customers tested assemblies and full logistics services.

ODU-UK Ltd. Phone: +44 1509 266433 sales@odu-uk.co.uk www.odu-uk.co.uk



A PERFECT ALLIANCE.

NORBAR - THE VOICE OF TORQUE CONTROL

- The widest range of torque tool products and measurement instruments
- Continuous investment in the latest machines and technologies
- ISO 9001:2008- certified Quality Management Systems
- UKAS accredited calibration laboratory- to ISO 17025:2008
- Sales offices in UK, USA, Singapore, China and India
- Global distributor network for sales, service and calibration
- Over 70 years of design innovation
- Skilled and knowledgeable staff with individual training and development plans
- New 15,800 sq. metre production site

CONTACT: +44 (0)1295 270333 enquiry@norbar.com www.norbar.com



View our NEW EvoTorque[®]2 video

The flight of the dragonfly

A UK team is taking its inspiration from the insect world to develop a surveillance drone. Jon Excell reports



n one of the key scenes from the 2015 thriller *Eye in the Sky*, British spies gather some vital intelligence on suspected suicide bombers by flying a tiny robot insect into the heart of a terrorist compound.

It's a compelling illustration of a capability that, as far as we know, doesn't yet exist. And it's a vision that a team of UK engineers and scientists now hope to make a reality through the development of a small surveillance drone that mimics the behaviour of one of nature's

most accomplished aviators: the dragonfly.

Over the past year Oxford University spin-out Animal Dynamics has been working on the development of Skeeter, a tiny flapping winged drone specially designed for covert surveillance. Weighing no more than 30g, and designed to cost less and fly for longer than other handlaunched drones, it could, its creators claim, help reshape urban warfare. With a DSTL-funded concept study under its belt, the firm has now been awarded additional DSTL funding, as well as support through the MoD's recently launched Innovation Initiative, to develop a fully functioning prototype that it claims could be ready to fly within 18 months.

Established to exploit some of the incredible technical solutions provided by the evolutionary process, the firm's technical pedigree comes from its chief science officer, Oxford University biomechanicist Prof Adrian Thomas.

A world-leading expert on animal movement, Thomas – who wrote a seminal paper on dragonflies back in 2004 – has something of a soft spot for the insects. "Dragonflies are fantastic," he enthused. "About a quarter of them migrate from Africa to here in a single individual continuous flight. That's an astonishing flight performance."

What's more, thanks to an airframe that's been optimised over hundreds of millions of years, they're also capable of incredible accuracy. For instance, the darter dragonfly – a common sight throughout in the UK in the summer – catches prey on around 90 per cent of its flights. "If you look at Patriot missiles more than 90 per cent of the time they fail to hit the target," said Thomas, "so there's obviously something special in the airframe."

One of the keys to the insect's aerial ability is the fact that it has independent muscles on each of its wings, allowing for greater bursts of acceleration, and more nimble manoeuvring than most other flying creatures. "They can flap them all independently and turn the flapping on and off," said Thomas. "They can even choose to glide if they want to."

He added that compared to birds or two-winged insects – where the length of the stroke, and angles and twist of the wing all have a bearing on flight – dragonflies also have a relatively simple control system.

All of this makes them a great model for a miniature drone and Thomas is confident that he'll be able to provide the MoD with a device that replicates the efficiency, agility and accuracy of this creature. "We need to be able to exceed the performance of dragonflies on every measure," he said. "We've got carbon-fibre and man-made motors, and we've managed to be an order of magnitude better in the wings and motors – we should be able to do it." >>

"Dragonflies can flap their wings independently and turn the flapping on and off. They can even choose to glide if they want to"

Prof Adrian Thomas, Oxford University





>> At the end of the expected 18-month development time, the firm hopes to be able to demonstrate a vehicle with what Thomas enigmatically describes as a "militarily useful" flying time. For reference, the Black Hornet, a helicopterbased micro-UAV that's currently used by British forces, is reportedly able to stay aloft for around 25 minutes.

Designed to be operated remotely, the vehicle will also be equipped with a level of autonomy that will enable it to perform manoeuvres such as hovering and following walls: thereby enabling it to continue operating in GPS-denied environments. Thomas added that it will offer considerable advantages over helicopter-, or quad-copter-based devices, which are far more prone to being buffeted by gusts of wind.

The final device will come in at just under 30g with the payload, which is also being developed by Animal Dynamics, accounting for approximately half of this weight. "On something of this scale everything has to have at least three uses so everything has to be integrated," he explained. "There's no spare mass. For example, if we save a bit of weight in sensors, that immediately goes into the battery to get a bit more lifespan." The weight has been further reduced by design of the wings: exceptionally lightweight and durable structures made from individual carbon-fibre strands covered by a polymer membrane.

As well as weight, the team is also focused on cost, and wherever possible is making use of COTS (commercial off-the-shelf) components. The most obvious example of this is in the batteries, where continued improvements driven by the mobile-phone industry have helped deliver power densities the team could only dream of 12 months ago.

Perhaps the most critical innovation, said Thomas, is the development of an exceptionally high power-to-weight ratio motor. And although he wouldn't be drawn on the finer details, he believes the system the team has developed could have a host of lucrative applications beyond the

Indepth

Flapping propulsion system could be the key to new water-speed record

In parallel with the Skeeter project. Thomas and Caccia have been gearing up for a crack at the human-powered water-speed record using a boat equipped with a flapping propulsion system. It's an approach to marine propulsion that Thomas claims has huge advantages over the incumbent technology. "With propellers the tips go too fast and the root goes too slow. At one particular speed it's correct and really efficient, but over a broad range of performance there's no doubt whatsoever that flapping-tail propulsion is more efficient. If you want something that's capable of going slowly and capable of going fast, and is efficient over all that we're using the wrong solution." Thomas hopes that the attempt on the record (which currently stands at 18 knots) will raise the profile of the technology. Flapping propulsion also has potential as a more ecologically friendly form of marine power generation, he added. "One of the nice things about a flapping foil-based hydropower generator is that the gearing's really high so the foil moves quite slowly - slower than fish and other marine life - so it's ecologically quite sound."

military realm. "We've got options that will work well on electric cars, we've got beautiful options that will work well as pumps, and really nice systems for driving anything where you need a really efficient very smooth constant-force drive at a constant rate."

The firm's CEO Alex Caccia, declined to comment on the exact price of the system, but said he expects it to be considerably less than the Black Hornet (as previously reported by *The Engineer*, the MoD paid around £20m for just 160 units). "We've been building this from the start with COTS components with the intention of mass production so we're hoping we can get them down to a small enough cost where the military will use swarms of them."

For the moment the focus is firmly



02 The Black Hornet Micro drone currently used by UK armed forces





Requirement: Intelligence, Surveillance, Reconnaissance

Li some or

Operation: Multiple environments, including Complex Urban Environments

Innovation: Bio-inspiration, Disruptive Capabilities

Developed for the MOD under the STRATUS Project by Animal Dynamics, UK SME

on the military applications for the technology, but in the longer term Thomas thinks that cracking the challenge of building military microdrones could open the door to a host of other applications.

"I think there's a good chance we could scale this up and provide a nice delivery-drone solution that is much more friendly and safe as a thing interacting with the person it's delivering to – much less likely to chop their arms up. Also – if it fails it will glide." (a)



Busted! This company's QA program AND reputation

It's hard to put the pieces back together once a real world product quality disaster strikes and the cost of a recall will be far, far greater than not investing in a quality assurance program in the first place. With our broad spectrum of physical testing machines, software, and technical support, Tinius Olsen can help you assure quality from material to end product. Reputations (yours <u>and</u> ours) depend on it.



DART

Articulating Videoscopes.

Your chance to buy one of the smallest on the market at up to 25% **OFF**.

The VJ-ADV series from RF Systems enables you to inspect previously hard to reach areas.

- 4 way articulating head
- Capture images, video & audio
 Runs on battery and mains



Call us now for details and prices. Full specification available on our website.

T. + 44 (0) 1761 432041 • F. + 44 (0) 1761 432042 enquiries@dartsystems.co.uk www.dartsystems.co.uk



10:1 Input dc-dc converter 240/280W

The HR series of dc-dc converters are designed for use in transportation and other advanced electronic systems. The extremely wide input range of 12Vdc to 168Vdc and configurable output provides a single unit solution for a vast range of applications. Features include high efficiency, high reliability, low output noise, and excellent dynamic response to load/line changes.

The converters are particularly suitable for railway applications operating from all common dc traction supplies: 24V, 36V, 48V, 72V, 96V, 110V & 120V nominal voltage. The converters comply with EN51055 and EN50121-3-2, IEC/EN 60950-1, IEC61000-4-2, -3, -4, -5, -6.

The output is configurable as 12Vdc, $\pm 12Vdc$ or 24Vdc; LED indicators display the status of the converter. They can be plugged into a 19'' rack system according to IEC60297-3, or be chassis mounted. Cooling plates are available for conduction cooled applications or heat-sinks for convection cooling.

Extremely wide input range 12 to 168Vdc Inrush current limitation Input overvoltage protection Programmable undervoltage lockout Zero load, overload & short-circuit proof Parallel operation with current sharing High efficiency to 94% Very high reliability Operating temperature range -40°C to +71°C

POWER DISPLAYS EMC

www.relec.co.uk

Tel: 01929 555800 e-mail: sales@relec.co.uk



Made to measure

The National Physical Laboratory's CEO is seeking to use metrology to boost the UK's prosperity. Andrew Wade reports



ittingly, my interview with National Physical Laboratory (NPL) CEO Peter Thompson took place in the Institute of Engineering and Technology's (IET) Turing Theatre, just a few minutes before he was due to take the stage. Turing himself worked for NPL after the war, and it was there that the great man devised his plans for the ACE computer in 1946.

Some 80 years later, the man now in charge of the organisation was there to launch NPL Instruments, a new commercial service that will build on existing capabilities in an effort to better serve industry. It's a project Thompson is clearly passionate about, and something he's been working towards since taking over NPL in September 2015.

"We already have an instruments' capability, and what we're doing is wrapping our arms around that and saying we can do this far more effectively," he said. "Often we might work on instruments and get it to a certain stage that develops the knowledge, and then move on to the next instrument, whereas we can actually take that further up the technology-readiness levels."

NPL Instruments is essentially a new business stream where a dedicated team will look to explore new commercial opportunities for the work already being done by the lab's 600-plus measurement scientists. Much of that work involves partnering with some of the biggest public and private scientific organisations in the world, including NASA, CERN and ESA, as well as UK bodies such as the MoD and DEFRA.

"We're a national lab, we're mission-driven, we're owned by government, and our mission is to provide that underpinning measurement capability for UK prosperity and quality of life," Thompson explained. "It doesn't get more important at this point in time for the UK that we're able to support industry, enable it to export, and to take on some of the big societal challenges.

"To do that, you need to understand what the big challenges are in the future that measurement can help with, be that energy and the environment, health and life sciences, advanced manufacturing or digital."

Metrology – the science of measurement – lies at the very core of technological advancement, and the ability to accurately measure the world around us has underpinned our scientific progress. By improving accuracy we remove uncertainty, something that is increasingly important as engineering projects grow in complexity.

Days after speaking with Thompson, the 2018 launch date for the James Webb Space Telescope (JWST) was



"It doesn't get more important at this point in time for the UK that we're able to support industry, enable it to export, and to take on some big societal challenges"

confirmed. With a primary mirror roughly seven times bigger than Hubble's – which will unfold only once it has been launched on a rocket and is 1.5 million kilometres from Earth – the JWST is the epitome of complex engineering. NASA uses some of the most accurate machines in the world to craft the mirrors for its space telescopes, and NPL provides the laser systems that control and operate those machines. If you don't get things right on the ground, Thompson explained, you have major problems in space.

"In ESA, for example, when it launches future missions, it needs to know that all of the separate component parts of a satellite do not impact on the performance of the satellite when it's out in the far reaches of space," he said.

"When one part of a satellite is woken, it may produce a miniscule vibration that actually means the satellite cannot perform its primary function. So you need to be able to test these individual components in an environment in which they have six degrees of freedom... so that you can measure whether they produce an actual vibration or a force themselves.



01 NPL played a key role in the manufacture of the mirrors for NASA's James Webb Space Telescope **02** NPL's UK headquarters in Teddington "We've developed what is essentially an anti-vibration table, which is borne out of a lot of the work we've done in dimensional and mass metrology in the past, so that ESA can test these components and give itself much greater confidence that they are going to operate in the manner that ESA wants them to once they're in space on that mission."

Thompson has a PhD in molecular electronics and spent many years of his career in the defence sector, including the Defence Science and Technology Laboratory (DSTL) and the MoD's Counter Terrorism Science and Technology Centre. I asked him how his experience in defence and security would influence the direction of the NPL.

"We already do some work in the defence sector," he said. "DSTL supports NPL in the development of some quantum instrumentation, miniaturised atomic clocks. So there's already a strong relationship between NPL and the defence and security sector.

"Perhaps what I'm bringing to NPL is a real focus on impact and working with the end user, understanding what the end user needs. You have a very clear focus on that if you're working in defence and security, and operations are underway. You need to make sure you're developing solutions that will work in the hands of the end user. And that means spending a lot of time with the end user, not just – as we used to describe – doing 'drive-by' research where you come up with a smart idea, throw it over the fence and drive off to go and do something more interesting that's often of no use to the end user."

That customer-led focus is a theme that underlies NPL Instruments. A key goal will be to help industry and academia bridge the notorious 'valley of death', the graveyard where much scientific research ends up after failing to deliver commercial value.

"It's difficult to argue against the statistics," said Thompson. "When you look at the amount of papers we produce, the academic excellence of the UK, and then compare those measures with how other countries innovate and pull through, clearly the statistics are not in our favour, despite being a very innovative, creative nation."

Thompson believes national organisations such as NPL and Innovate UK need to play a more prominent role in overcoming the valley of death, simplifying engagement and communication between industry and academia.

CareerCV

Peter Thompson Chief executive officer, NPL

- Following a PhD in molecular electronics, worked in trace analytical chemistry for the Defence Research Agency and Defence Evaluation and Research Agency.
- Held a variety of technical, project and programme roles before joining the Defence Science and Technology Laboratory (DSTL), where he undertook business unit leader and customerfacing roles in intelligence, surveillance and reconnaissance for defence and security.
- Became head of the Counter Terrorism Science and Technology Centre, before a return to DSTL as programme director for science and technology.
- Following a period in the Ministry of Defence headquarters, where he joined the senior civil service leading science and technology policy, Thompson returned to DSTL as a board member and deputy chief executive, responsible for corporate strategy, governance, strategic relationships, communications and human resources.
- Took up his present role at the National Physical Laboratory in September 2015.

"We can provide that bridge between the two communities," he said.

In the aftermath of the Brexit vote, both those communities now face increased uncertainty. Industry is wary of tariff and customs complications, while funding for research could come under threat in the Article 50 shake-up. International collaboration, which is at the heart of much of today's leading scientific activity, could also be hampered by the introduction of immigration controls. Measurement is, by its very nature, reliant on transnational cooperation and agreement on accepted standards, and NPL is very much an international organisation.

"I'd lose the faith of my own folks, and anybody reading your magazine, if I said as a CEO that I didn't worry about the implications of Brexit," said Thompson. "I think it's very early at the moment to make any confident predictions as to how this is going to play out. My primary focus since the end of June has been to do what I can to reassure the many nationalities that we have working within NPL.

"The measurement system is a global system, it is reliant on international comparisons between national measurement institutes. We're very proud to have in excess of 40 different nationalities represented within NPL... who've been here for a week, or for 20 years. And as somebody said to me earlier, when you work within NPL you wouldn't know that somebody was from one country and somebody else was from another one. We work as a team, we're very proud of that, and we hope to maintain and, if anything, build on that. It's at the very heart of what NPL is, and what NPL will be in the future."

scifi eye | jon wallace



Still seeking Iffe on Mars

Novelist Jon Wallace considers the science fiction implications of engineering stories that have caught his eye. This month, the planet Mars continues to weave its fictional spell



ne might have expected the science fiction fan to have given up on Mars by now. To the Moon-shot optimists of the 1960s its colonisation seemed moments away; its surface would be littered with the

structures of the civilisation promised by 19th century science: Lowell's canal builders and Tesla's radio hams. The Moon's conquest would be a mere stepping stone to the bloody disc beyond.

The last half-century has failed to deliver on the promise of life on Mars, or even its remnant. The Viking programme and its successors provided only cold proof of the planet's lifelessness. Our own commitment to colonisation has correspondingly diminished: the West's most vocal proponents having something of the eccentric about them. Enthusiasm is further suffocated by the evident peril of the journey. Mars has a habit of swallowing up expeditions: NASA's Climate Orbiter and Polar Lander, Europe's Beagle 2, Russia's Roscosmos and, most recently, ESA's Schiaparelli lander.

Yet scifi's enthusiasm is undiminished: from Pierc Brown to Andy Weir, authors continue to be drawn there. Stories such as *The Martian* and Kim Stanley Robinson's *Red Mars* embrace the science behind the challenges, delivering excitement and intrigue by the masterful intertwining of human elements – isolation and survival against the odds in one; sex and politics in the other. Mars seems to belong to books; its decimated landscape lends itself to the most epic instincts, given life in works such as Dan Simmon's *llium*.

Hollywood rather struggles with the Red Planet, churning out a regular stream of Mars flops (*Red Planet, Mission to Mars, Last Days on Mars*). Yet the studio execs persist, as hypnotised by Mars as the ancient astronomers, their most successful pictures proving to be book adaptations: *The Martian* and *Total Recall.*

Why, then, the continued fascination? Are the tantalising false alarms of Cydonian faces and meteorite 'fossils' to blame? Is it the more obscure promise of preserved alien specimens locked in



Mars holds a mirror to human constructs and offers boundless space for stories

"Hollywood has always struggled with the Red Planet, churning out a stream of Mars flops"

Jon Wallace

water ice or impact crystals? Or could it simply be the blank-red slate that the planet offers the writer, the "mythic arena" Carl Sagan described?

Certainly, the Mars landscape holds a mirror to human constructs, and offers boundless space for stories. When we consider its vast geological features it's easy to imagine the planet becoming an adventure playground for some future Branson, a billionaire adventurer who sets himself one of those curiously human challenges: to be the first man to climb Olympus Mons. Having claimed Mars' most outstanding features, he establishes the world's first space resort, nestled in the Hellas Planitia impact basin; a place from where Earth's super rich (and super bored) may go base-jumping into Valles Marineris and spelunking in the Seven Sisters caves. The resort is short lived: a separate landing party of genetically engineered terraformers lose their provisions in a crash. Starving, they employ their unique infrared vision to raid the wealthy resort under cover of a dust storm, stripping it of supplies and making slaves of its guests. Future Branson protests, but all the money in the world can't buy back Mars – a planet where man is returned to a prehistoric struggle for survival.

The Martian hemispherical dichotomy itself presents possibilities: we could tell the tale of Mars aliens not as one ancient civilisation but as two: peoples so identified by their landscapes (the stormy, mountainous south and the milder flat north) that they are never able to overcome their tribal division, making war relentlessly until some terrible weapon brings about final destruction. Millions of years later, a human colonial mission lands parties on each hemisphere. Each discovers artefacts of the ancient races, and become infected by the same tectonic prejudice. As the years pass the two grow equally suspicious and hostile to each other, reviving the ancient causes as their own – as if tribal rivalry is some essential foundation of civilisation.

Perhaps, donning our tinfoil hat for a moment, we might imagine that rather than colonise Mars, the Earth has been occupied by Martians. In this alternative history, Tesla really did hear those radio transmissions – accidentally eavesdropping on communications between Martians and their proxies on Earth: ageless shapeshifters whose centuries on freezing Mars have given them a perpetual craving for more and more heat. Viewing us as useful monkeys, they manipulate us into warming our climate. All those terrible movies, it turns out, have been produced by them; their way of keeping their planet safe from our serious contemplation.

Yes, these ideas are all based on conflict, but Mars has that effect on us: it's the colour of blood, named after a god of war. Its dormant plate tectonics and faded magnetic field remind us that all the civilisation we are so often called to fight for represents but a blink in time. What then, is its meaning? We're not exploring a planet in Mars literature. We're exploring ourselves.

Jon Wallace is a science fiction author living and working in England. He is the author of the Kenstibec trilogy, published by Gollancz

Tom Parker Ltd – First for FasTest®



Quick leak test and pressure test connectors and valves for the industrial manufacturing, HVAC-R and compressed gas industries



Maximising Efficiency, Productivity and Profitability



NEW WEBSITE Tom Parker Ltd, Marsh Lane Mill, Marsh Lane, Preston PR1 8RT w: tom-parker.co.uk | e: sales@tom-parker.co.uk | t: 01772 255109 | f: 01772 563475

Subcontract sawing





Accurate Cutting Services can cut any metal, ferrous or non-ferrous to close tolerances to resize stockholder material, recover or reuse material or enable internal inspection and testing of castings and forgings prior to full production. We can handle up to 25 tonne loads, 2000mm dia, 8000mm long, and sometimes **bigger**.







Advantages of sawing:

- No deformation through pressure
- · No heat affected zones minimal machining or waste
- No damage to base materials cold process
- Cutting of materials or items up to 2000mm thick
- Reusable offcuts not turned into expensive swarf
- Enables recovery and reuse of metals or re-purposed
- castings, forgings, machined components very cost effectively
- Sectioning of large components for inspection and test pieces







The FasTest Range

FasTest[®] FI Series FasTest[®] FE Series FasMate[®] FN Series FasMate[®] FX Series

EZ Connect[™] ZF EZ Connect[™] ZN

Twistmate[®] MET Threaded Connectors

Twistmate[®] MIT Threaded Connectors

only available at Tom Parker Ltd

What's in a sub's name?

Britain's new nuclear submarine will be called *Dreadnought* – a moniker with a long history. Stuart Nathan reports



he first of the new submarines that will carry Trident missiles when the UK's nuclear weapon programme is renewed is to carry the Royal Navy's most famous name.

The submarine, which will be built at BAE Systems' manufacturing site at Barrow-in-Furness, Cumbria, is to be called HMS *Dreadnought* and,

as is traditional, the three other nuclear missile-carrying submarines will be known as the Dreadnought class and their names will all begin with D.

Dreadnought will replace the Vanguard-class submarines that currently carry Britain's nuclear missiles. *Vanguard*, *Victorious*, *Vigilant* and *Vengeance* began to come into service in 1993. Construction of *Dreadnought* began last month. No date has yet been given for its entry into service, or of any other of the submarine's specifications. The cost of building the four submarines is expected to be around \pounds 31bn.

The *Dreadnought* name has been used for nine other Royal Navy ships in the past, the first being sailed by Sir Francis Drake when he fought the Spanish Armada in 1588. Another was one of Nelson's fleet at the Battle of Trafalgar.

The most famous *Dreadnought* was arguably a battleship that was launched in 1906, which, at the time, was the most heavily armed and armoured naval ship in the world, and that contributed to the arms race in the run-up to the First World War (see box). ®

Thearchive

HMS *Dreadnought* was a key factor in the 'balance of power' in 1906

The Engineer covered the launch of the most famous HMS Dreadnought in February 1906. The ship was launched at Portsmouth by King Edward VII to much public interest. "She has been frequently spoken of as if she marked an entirely new departure in naval architecture. This is not strictly true," the journal reported. "She evolved from types which preceded her, and the apparent jump is caused, not a little, to the fact that her immediate predecessors are still far from completion." The public interest, *The Engineer* commented, was due to the ship's size, turbine engines, fighting power, the speed it was built, and the secrecy with which the project was surrounded.

In an almost eerie paragraph, *The Engineer*'s report notes the geopolitical significance of the project. "We are prone to forget that the peace of Europe reposes in the maintenance of a certain balance of power, which might be easily upset by changes in one navy or the other, but we must not be blind to the significance of the speed with which the *Dreadnought* is being built. The *Dreadnought*... is meant as an object lesson which those who are intended to learn cannot fail to appreciate. We know that she is closely observed, and that other nations will at the earliest moment seek to produce a 'reply' to her, and it is clearly wise policy to retain the lead which we possess by concealing as long as possible details of her design and strength."



HMS Dreadnought will be built at BAE Systems' manufacturing site at Barrowin-Furness



Full Mazak range





Smooth Technology, hybrid, multi-tasking, laser and state-of-the-art automation are just a few of the solutions provided by Mazak.

Yamazaki Mazak is the world's largest manufacturer of computer controlled metal-cutting machines. With over 260 different models, the Mazak product range includes CNC lathes, machining centers, multi-tasking machines and flexible manufacturing systems as well as laser processing machines.

Visit www.mazakeu.co.uk for more information.



Yamazaki Mazak U.K. Ltd. Badgeworth Drive, Worcester WR4 9NF

T: +44 (0)1905 755755 F: +44 (0)1905 755542 W: www.mazakeu.co.uk E: sales@mazak.co.uk







COMPACT SIZE compact price



COMPACT SERVO

The combination of absolute encoder and high strength polymer gears redefines the brushed DC motor as a powerful, low-cost servo.

Call or visit our website to find out about this revolutionary concept produced with engineers in mind. www.**rotalink**.com +44 (0)1460 72000

Rota ink

Rotalink Ltd • Cropmead • Crewkerne Somerset • TA18 7HQ • UK

Technology is your enemy. Technology is your friend. You want the best technology on your side.

> Taranis Unmanned Combat Air Vehicle Demonstrator



www.baesystems.com



AEROSPACE

Thrust into outer space

Centre will build propulsion systems for geostationary satellites HELEN KNIGHT REPORTS



The new space facility in Belfast, Northern Ireland

hales is to produce a set of electric propulsion systems for geostationary satellites in the UK, following the opening of a new

space facility in Northern Ireland. The astronaut Tim Peake officially opened Thales' Space Propulsion Integration Centre in Belfast on October 2016.

Known as Hall-effect Thrusters, the

AUTOMOTIV

Engine blocks move on to the casting couch

Grainger & Worrall set to work on DB11 car

STUART NATHAN REPORTS

Grainger & Worrall has secured a contract as preferred partner for casting the engine blocks for Aston Martin's DB11 model.

The DB11 will be equipped with a

propulsion systems use electrical energy collected from the sun to accelerate inert Xenon gas from an electric thruster. The electric thrusters have an exhaust velocity of approximately 10,000m per second, or between 50 and 100 times the speed of sound in air.

This can reduce the cost of launching a satellite, or allow them to carry larger loads, according to Dougie Davidson, head of space programmes at Thales Belfast.

5.2l, twin-turbocharged, 48-valve V12

engine developing 600bhp, and is

claimed to be the cleanest, most

fuel-efficient, most powerful and

performance of 3.9 seconds.

thermosetting resin.

fastest-accelerating car from Aston

Martin, with a claimed 0 to 100km/h

Grainger & Worrall's Wolverhampton

by 3D printing specialist sand and

recyclable aluminium alloy, and the

parts will then be shipped to Aston

Germany, where they will be further

According to Grainger & Worrall,

Martin's engine plant in Cologne,

machined and assembled.

The engine blocks will be cast at

foundry using sand-mould cores made

The casting itself will be done using

"It makes it possible to carry a larger payload, or to launch a satellite at a lower cost because of the reduction in the amount of fuel that has to be carried," he said. "It can save approximately 400kg of launch weight for a four-tonne satellite."

Electric propulsion systems use around one-fifth of the propellant used by conventional chemical engines. This is particularly important at a time when the economics of space propulsion are in the spotlight, said Davidson.

The facility is part of an investment programme by Thales to expand space design and manufacturing in the UK, after the company formed Thales Alenia Space in 2014. This investment programme will also include the expansion of space engineering centres at Bristol and Harwell.

The company plans to build four geostationary satellite propulsion modules each year at the facility, Davidson said.

"The geostationary satellite is the largest class of satellite, and we have some capacity to produce smaller satellite propulsion systems as well," he added.

The decision to invest in space engineering and manufacturing in the UK was also partly due to the government's efforts to promote the industry, the company said.

These efforts include securing a significant share of the European Space Agency's Neosat programme for the UK.

The Neosat programme aims to develop new technology platforms for three- to six-tonne geostationary satellites. Its ultimate goal is to enable Europe to take a 50 per cent share of the global geostationary satellite market, said Davidson. (e)

the 3D printing of the mould cores was necessary because of the highly complex CAD files produced by the design team, which involved a close collaboration between its own designers and Aston Martin's to ensure that the engine was light and powerful.

Grainger & Worrall has a longstanding relationship with Aston Martin, along with other performance marques. It has also produced engine castings for motorsport series including Formula One. The company is notable for its pioneering use of CT scanning as a quality-control technique, to ensure the dimensional compliance of the castings with original drawings and the integrity of the metal within the casting block.

Newsinbrief

Rate of expansion

The UK's manufacturing sector maintained a firm rate of expansion at the start of the final quarter, with October's Markit/ CIPS Purchasing Managers' Index posting 54.3. Dave Atkinson, head of manufacturing at Lloyds Bank Commercial Banking, said: "Manufacturing activity remains at its highest level since January, and the fact that firms have maintained a positive outlook amid an uncertain landscape and a devalued pound is something to be applauded."

Heads up

Artemis Optical has entered into a 10-year agreement with BAE Systems to supply Head-up Display (HUD) assemblies. Artemis will draw on its experience in the design and manufacture of HUD combiners' assemblies for incorporation into BAE Systems' LiteHUD products until 2026. Artemis expects to employ additional personnel such as coating technicians and assembly staff.

More optimistic

Optimism among Britain's SME manufacturers increased over the past quarter, and export prospects for the year ahead have risen too, according to the latest CBI Quarterly SME trends survey. The survey reported that total new orders edged up in the last quarter, while output rose modestly.

Saving water

Ford Motor Company is aiming to reduce its use of water in manufacturing. By 2020, Ford hopes to have reduced its water usage per vehicle by 72 per cent and will have saved more than 377 billion litres of water since the turn of the millennium. For every 3.7 litres of water Ford used in 2000, it aims to use about one litre by 2020.



Pods are coming up in the world

Coventry manufacturer RDM Group is making a name for itself at the vanguard of driverless car technology. Andrew Wade reports

> he West Midlands has long been home to some of the UK's most innovative manufacturers. But one of the most interesting names to emerge in recent decades is Coventry engineering group RDM, which, over the past two decades, has established something of a name for itself as a key supply-chain partner for the automotive, aerospace, medical, rail and renewable sectors.

Most recently, the group has emerged as a major player in the UK's driverless vehicle sector.

The firm cut its autonomous teeth in the LUTZ (Low Carbon Urban Transport Zone) Pathfinder project – an

initiative led by the Transport Systems Catapult that saw it develop a number of two-seater driverless pod cars that are being used in one of the UK's first public trials of fully autonomous vehicles. Even more recently, it unveiled a scaled-up version of the LUTZ pod, a four-seater autonomous vehicle named Pod Zero, a driverless pod specially designed for public spaces, which the firm is in the process of showcasing to interested parties around the world.

The Engineer recently caught up with the group's autonomous vehicles programme director Miles Garner, and asked him about the firm's bold plans to become a key UK manufacturer in this rapidly emerging sector.

"We won the contract about two-and-a-half years ago to build the LUTZ pods," said Garner, "us and Oxford University, who worked on the sensor pack."

The project drew to a close in October with a public demonstration, but the wider UK Autodrive programme it was a part of will build on the lessons learned over 18 months of LUTZ trials. The pods used an autonomy software system called Selenium, developed by Oxford University spin-out Oxbotica. RDM designed and built the vehicles, but the experience merely whetted its appetite to explore the driverless market. The result is Pod Zero, designed from the ground up by RDM, with a wholly owned hardware and software system.

"On the back of LUTZ we actually took it upon ourselves to commercialise the proposition," said Garner. "The LUTZ pods were really one-off commercial prototypes, so we decided to make our own commercial version, totally different to the LUTZ, and also using our own autonomous control system as well."

RDM currently has capacity to manufacture about 200 pods a year at its Coventry headquarters, but CEO David Keene has hinted the company could move to a new purpose-built facility nearby. However, expansion is contingent on demand for Pod Zero.

"It really does depend on the market," said Garner. "We're currently having lots of conversations with lots of governments and companies that want to offer the pods around. These can be trials of two or three vehicles, or up to about a hundred."

One of those conversations is with investors in the

01 RDM Group's Pod Zero vehicle

02 The Land Rover Defender Leopard II vehicle

03 Inside RDM's engineering centre

04 The firm developed the pods for the LUTZ Pathfinder project Middle East looking to use the pods to transport guests around a massive indoor shopping complex. The region is already home to the world's biggest mall in Dubai, with several more gigantic shopping projects planned. Electrically powered pods would be a suitably high-tech way to transport customers around these retail megalopolises. With airports and university campuses also strong contenders for adoption, it's not hard to see why RDM has pursued the autonomous route, despite the challenges involved.

"On the actual pod itself, the learning curve was quite steep," Garner explained. "As a company in the past we've actually built cars from the ground up, so we've got lots of experience with building the different aspects of the vehicle. But when we took it upon ourselves to carry out our own autonomous system, we had to take on a lot of people."

As well as investing heavily over the past number of years in the technology underpinning Pod Zero, RDM also recently opened a new Advanced Engineering Centre. A £400,000 investment ensured the facility was fitted out with the latest equipment, including two state-of-the-art CNC machines, three injection moulding machines, a three-axis router, and a laser engraver. Engineers there also have access to the latest CADCAM software, working with customers from



"When we took it upon ourselves to carry out our own autonomous system, we had to take on a lot of people"

Miles Garner, RDM Group





early development through to finalised designs. The centre enhances RDM's ability across a range of services, from prototyping and electronics, to machining and telematics.

"We took on the centre because we found that we're picking up, primarily from JLR, lots of prototyping work," said Garner. "Plus, also, we carried out quite a few technology rebuilds."

One of those rebuilds included the Land Rover Defender Leopard II, where RDM fitted seven of the iconic off-road vehicles with electric drivetrains. The

Leopard is propelled by a 70KW 330Nm switched reluctance drive motor, powered by a passively cooled lithium-ion P04 27KW/hour 300V battery mounted in the former engine compartment.

The experience with Land Rover helped convince RDM that investment in an Advanced Manufacturing Centre would be a worthwhile endeavour, and also helped develop its expertise around electrical vehicles. The 20,000ft² centre officially opened in 2014, providing the company with a dedicated facility to take on ambitious new vehicle builds, as well as development work on a host of components, primarily for the automotive sector.

"We're able to do our own carbon fibre, which we do for JLR and also for Aston Martin," said Garner. "For interiors, we have a trim shop now, so we do lots and lots of trim."

Although about 80 per cent of revenues still come via automotive, RDM's capabilities meant it has branched out into other areas of manufacturing, albeit at the behest of one of its biggest automotive clients.

"There's a torch we produce that is very high-end quality," said Garner. "It's a Maglite-type torch that is offered as a premium accessory for JLR vehicles, and we actually build that ourselves. We've got the turning machine, the five-axis CNC machine, so we have all the capabilities to do that in-house."

While RDM's UK capabilities continue to expand, the company is also looking at options further afield. Autonomous technology is advancing rapidly and the company is in a great position to capitalise on the burgeoning market. But the really big opportunities are likely to lie beyond the confines of the UK.

Garner is enthusiastic about unlocking the potential value of markets in the Asia-Pacific region. Growth there may have slowed compared to a decade ago, but it still far outpaces that of Europe and the US.

"We've had lots of interest in the US, also over in the Far East and the Middle East," said Garner. "But Australia would really be a perfect type of location to actually build a factory. It would help us to take on the whole Asia-Pacific Rim area if we had a place in Australia. As an engineer, it really is an open door. There's lots of help from the government, especially the South Australia government... out of the whole world, I'd say the Asia-Pacific Rim region is the biggest opportunity for us." (

AUTODESK.

AUTODESK POWERMILL

The expert high-speed and multi-axis solution

Need complete control over your mold and die machining process? Autodesk PowerMill maximizes efficiency and quality from your 3-axis, high-speed, and multi-axis CNC machines for the manufacture of highly complex parts.

> www.powermill.com T: 0121 683 1000 E: mfg-uk@autodesk.com

Making medical moves to high-speed milling

Machining centres enable toolmaker to increase turnover and cut lead times

A move from electric discharge machining (EDM) to high-speed milling has helped Irish toolmaker Galway Tool & Mould (GTM) cut its lead times by up to 20 per cent.

The company – which employs 30 engineers at its Galway facility – specialises in the manufacture of high precision injection moulds for the medical, pharmaceutical and high-volume packaging sectors.

With the medical sector demanding tight tolerances, excellent surface finishes and short lead times, the firm found that the EDM techniques it was using to produce moulds were becoming too time consuming, so it made the decision to instead use high speed machining wherever possible.

According to shop-floor manager Mark Walsh, since investing in three German-built Roeders machining centres supplied by High Wycombe firm Hurco Europe, the firm has shaved as much as 70 per cent off key areas of the manufacturing process.

This has led to a doubling of turnover between 2012 and 2015 and an increase in floor area from 4,000 to 15,000ft², with an extension of an additional 8,000ft² currently being added.

More recently, work has been more heavily centred on pharmaceutical moulds, entailing machining of even greater complexity that requires multiple set-ups on a three-axis machine, the use of long cutters to access awkward areas from above, and repeated repositioning for side features to be included.

A five-axis vertical machining centre (VMC) was the obvious solution, so in May 2015 a Roeders RXP601 DSH with a 96-tool magazine was installed, again with automation but this time provided by a 38-position pallet change system to allow longer periods of unattended running. A second RXP601 could be served by the same automation

equipment if required in the future. The advantage

of using five-axis machining on some jobs is dramatic. For instance, one of the company's products – an inhaler mould – was previously machined in a total of eight hours on a three-axis Roeders and an EDM machine in five operations. The five-axis HSC machine tackles the same job in a single set-up in one-quarter of the time – just two hours complete.

Alongside the move to high-speed milling, the firm has also invested in metrology equipment, recently opening a laboratory for tool validation and an in-house trial facility for moulds equipped with Fanuc electric moulding machines ranging from 100 to 300 tons capacity.

The latest innovation off-line set-up of jobs on a coordinate measuring machine, which, when fully implemented, will add an extra 10 hours of production per week across the three Roeders machines.®



Multi-tasking proves to be the turning point

Multi-tasking machines assist milling, turning, and electrical mechanical assembly specialist

Sustained investment in skills and machinery has helped Stroud-based subcontractor Truturn branch out from its local roots and establish a healthy export business.

The milling, turning, fabrication and electrical mechanical assembly specialist began life servicing the local engineering and manufacturing community, but thanks to a relentless focus on training and accreditation, and investment in the latest manufacturing technologies exports to Europe, the Far East and the US now account for almost a third of its business.

According to general manager Bob Wilkins, the firm's relationship with machine-tool supplier Mazak has been central to its transformation in recent years, with its investment in an Integrex j-300 – one of Mazak's multi-tasking machines – proving a key turning point.

"We knew that if we didn't invest in new machines, we weren't going to grow," said Wilkins, "not least because our customers were looking for us to take cost out of our processes and pass on the savings to them. I would say it was a culture shock for us when we started with it, but it has proved its worth and I would estimate that the Integrex j-300 has taken about 15-20 per cent of our costs out of the products.

The machine has had a positive effect on morale. "I have three guys on there who know the j-300 inside out, they've been on the training courses and developed their own skills, which is very positive for them. I also have one of our apprentices on there a lot and he loves it".

The Integrex system was quickly followed by a Quick Turn Nexus 250M CNC turning centre. "That machine has been a revelation for us, particularly in terms of us being able to put development and

prototype work on there. We've completed a wide variety of jobs on it, from tube through to complex blocks, but the key point is that we no longer have to complete a secondary milling operation, which means we've cut set-up times by 30-40 per cent."



Going forward, Wilkins believes the future for Truturn lies in five-axis machining and potentially a specialist milling machine. "The focus for us is five-axis now. We'll need some support from Mazak to get there, but that is where we want to go." (

Measurement is all in a single system

New multisensor CMMs can help save time in measurement tasks

have rotational symmetry, the workpiece can be clamped in using the CNC rotary axis, which can also be made to swivel on an additional axis. Both models can use the CMM monitoring system MMS PUL, which monitors temperature, vibrations, humidity and machine status to give operators a complete picture of the machine environment. According to Wolfgang Froehlich, commercial product manager at HMI, the 663 and 664 Dual-Z represent future-proof measuring systems capable of handling a variety of different tasks. "The innovative Optiv Dual-Z and Optiv dual rotary options help CMM users to find the ideal positioning of sensors and the workpiece limits," he claimed. **•**

Hexagon Manufacturing Intelligence (HMI) has launched two new multisensor coordinate measuring machines (CMMs), the Optiv Performance 663 and 664 Dual-Z. Both machines can be configured for both tactile and contactless measuring in a single system. To save measuring time, different workpiece features can be measured without re-clamping.

Both machines feature low-vibration granite construction, mechanical linear guides on all axes, backlash-free precision drives and integrated temperature compensation. The 663 model has a measurement range of $610 \times 610 \times 305$ mm, while the 664 takes the Z-direction up to 405mm.

Another feature of both machines is that they can be fitted with two independent vertical axes for optical and tactile sensors. This prevents the inactive sensor from impeding machine movement, Hexagon explained, so that features within the workpiece remain accessible for programming and the risk of collisions is reduced. Dual-Z technology also allows the use of a motorised indexable probe head to carry the tactile sensor. For those

workpieces that



Increasing turbine energy efficiency

CMMs help firm refine production of supercritical turbine blades



Sri Sai Durga Engineering (SSDE), a company specialising in supplying the power-generation industry in India, is using a Nikon Metrology Altera coordinate measuring machine to increase the energy efficiency of its production of supercritical turbine blades by around 40 per cent. The company, based in Patancheru, Hyderabad, has a particular focus on reducing lead times for components with challenging specifications.

Components for supercritical systems tend to need tighter tolerances, different dimensions and more complex shapes than those for conventional (sub-critical) power generation, whose turbines operate at a much lower pressure. This has made metrology more challenging for the company, and to maintain required levels of quality assurance it has needed new measuring equipment that combines speed, accuracy and automation.

To optimise steam flow within the turbine, supercritical turbine blades need to be much stronger and have a more complex design than those for subcritical turbines. They are made from a variety of custom alloys, as well as a composite known as X20, which is often used for high-temperature steam piping.

Self-critical turbine blades have a fixed section geometry, which can be measured using manual methods such as calipers. However, supercritical blades have a twisted aerofoil with varying geometry from root end to the shroud end; these are difficult to measure using manual methods, and particularly challenging within the short timescales to which SSDE works.

According to managing partner Naveen Reddy, a new automated system was necessary. "Customer satisfaction is always a priority in my business and limitations of the previous method would mean uncertainty and product quality, leading to customer dissatisfaction." Reddy consulted several CMM suppliers looking for a machine capable of fast, accurate inspection. The choice of the ceramic bridge 8.7.6 Altera with SP 25 continuous scanning probe and Digigraph blade analysis package part of the Nikon Metrology Camio software suite - has given the company accuracy and repeatability that has been a major bonus in inspecting components with complex shapes and contours.

Use of the Altera system has reduced inspection cycle times by at least 30 per cent since moving from manufacturing subcritical to critical components. According to Reddy, the Camio software's automatic best-fit feature has been particularly useful, as it helps the quality-assurance team be certain that inspector components conform to specification.



A NEW TOOL FOR LEARNING THE TRICKS OF THE TRADE: HOFFMANN GROUP TV.

The new "Hoffmann Group TV" video platform has arrived! You're just one click from all the information you need on our high-quality tools. Learn innovative handling techniques or simply revisit the basics and see how our tools can make your work that little bit better, so your business can reap the rewards.

www.hoffmann-group.com ab.uk@hoffmann-group.com / +44 (0) 87 04 - 17 61 11



Nikon Metrology provides optical and mechanical 3D metrology solutions, vision measuring instruments, microscopes, X-ray and CT inspection systems.



Coordinate Measuring Machines



X-ray electronics inspection



Laser scanning



Computed Tomography metrology CT





Large volume metrology



Video measuring systems



Industrial microscopes



Measuring microscopes



Portable microscopes

NIKON METROLOGY | VISION BEYOND PRECISION

For further information contact: Gemma Speed, UK Marketing Assistant Marketing.NM-UK@nikon.com • 01332 811349

www.nikonmetrology.com



Jetting ahead for complexity

System uses ultra-fine droplets of metal ink for higherquality and more detailed parts than are possible with existing additive techniques. Jon Excell reports



n additive manufacturing system that produces parts by jetting metal ink is to make its European debut at this month's Formnext show in Germany.

Developed by Israeli firm Xjet, the system is based on the company's so-called NanoParticle Jetting technology, which uses

ink jetting to produce complex metal parts from a suspension of nanoscale particles.

The firm claims the system represents a breakthrough in additive manufacturing and produces higher-quality, more detailed parts than is possible with existing metal additive techniques, most of which build parts from powdered metal.

The technology, which was demonstrated to the US market at the Rapid show earlier this year, uses solid metal nanoparticles suspended in liquid 'ink' in sealed cartridges.

During the printing process, ultra-fine layers of droplets of this ink, which also contains support structure nanoparticles, are deposited onto the build tray, where extremely high temperatures cause the liquid 'jacket' around the metal nanoparticles to evaporate. After this, a sintering process is carried out to fuse the metal particles together.

Critically, while many other techniques rely on uniform metallic particles, the particles used in the jet process are stochastic – i.e. of random shapes and sizes. According to the firm, this produces properly dense parts with no porous attributes, resulting in superior-quality metal.

Xjet also claims that the size of the particles and the ultra-thin layers that the process creates allows a level of detail that gives printed components virtually the same metallurgy as traditionally made metal parts. "Xjet's... technology produces complex geometries with intricate details, and with perfect metallurgy. This is unprecedented," said Yair Shamir, chairman of Xjet.

What's more, because the raw material is loaded into the machine in a sealed cartridge, the system is claimed to be

"People who use metal are primarily interested in the microstructure and I would say the metallurgy of the finished parts is as yet unknown"

Prof Richard Hague, University of Nottingham



01/02 Xjet's NanoParticle technology uses solid metal particles suspended in liquid as a feedstock

far safer and more user friendly than other systems, which require users to handle metal powders.

Xjet was founded in 2005 by inkjet printing industry veteran Hanan Gothait. He was one of the co-founders of Objet, which merged with 3D-printing giant Stratasys in 2012.

The firm employs 55 multidisciplinary R&D specialists and has filed more than 55 registered and pending patents. Earlier this year it announced that it had raised US\$25m in investment through a funding round led by Chinese private equity fund CEL and engineering software giant Autodesk.

However, it isn't the only organisation working on metal jetting technology. US start-up Vader Systems recently unveiled its so-called 'magnetojet technology', which uses an electromagnetic jetting system to produce 3D components from molten aluminium.

Meanwhile, in the UK, the University of Nottingham's EPSRC Centre for additive manufacturing has been working with Dutch ink-jetting specialist Oce on the MetalJet machine, which will be able to directly jet 3D metallics from print heads that operate at temperatures of up to 1,800°C.

Commenting on the Xjet technology, Prof Richard Hague, who heads up the Nottingham group described it as an interesting and promising approach, but suggested that the requirement for a post-processing sintering stage might lead to component shrinkage and distortion. "It will be interesting to see how it is going to manage these issues," he said. "People who use metal are primarily interested in the microstructure and I would say that the metallurgy of the finished parts is as yet unknown." (a)



opinion | metrology



Graphene needs to measure up

Measurement technology will be key to exploiting the advantages of graphene, says Starrett's John Cove



tronger than a diamond yet a million times thinner than a human hair, the properties of graphene are astounding. The market for this material may still be in its infancy, but graphene is already being hailed as one of the most disruptive

technologies of our time. For the composite market, there is no doubt that using graphene could open up a host of new possibilities.

Graphene provides incredible strength at an ultra-light weight. The technology is already being used in various ways, such as in the manufacturing of glass-reinforced plastic (GRP) composite road plates being used by utilities and infrastructure firms during road works. Major automotive manufacturers are also beginning to run research groups to test graphenebased composites for use in new vehicles. Regardless of its advantages, using graphene to its fullest potential is not without its challenges.

Research has shown that dispersing a small amount of graphene into polymer composites can dramatically improve a material's tensile strength, elastic modulus and electrical and thermal conductivity. However, because these graphene related materials (GRMs) are not yet fully scalable, product researchers and designers are yet to develop a comprehensive understanding of the technology.

The potential for graphene to reinforce a composite relies on a trade-off between the properties of the matrix material and the graphene itself. As a result, force measurement testing will need play a major role in ensuring simultaneous stiffness, strength and toughness of GRMs during the manufacturing process.

Currently, mass manufacturing data for graphene composites is not available and there is no tried-andtested method for the large-scale production of graphene-based products. While there is no denying that graphene composites are going to be a major trend, if GRMs are to dominate the market, they will require thorough testing to the same standard as established materials.

Composite materials are continually developing and the introduction of graphene adds another layer of complexity. As GRMs are completely new to the market, engineers will not be familiar with potential properties so will be unsure of what tests are required to measure tolerances. This is due to the fact that there will not be any existing data to draw from. As engineers begin to incorporate graphene into new composites, the challenge of accurate measurement can be overcome by using intelligent testing and measurement software.

Starrett's L3 software, for example, does not presuppose any prior knowledge of what measurements are required. Instead, the software will examine how the material is adapting and adjust the test based on this data. Naturally, the software will also test for common measurement data, such as tensile strength, tensile chord modulus of elasticity, tensile strain and transition strain. Once the test method has been created, a graph will automatically be generated, allowing the engineer to measure any point on the graph for tension, compression, flexural, cyclic, shear and frictional forces.

The properties of graphene are fascinating and the possibilities it affords the composite market are exponential. However, to truly deliver design engineering excellence using graphene, innovation in measurement must come first.

John Cove is marketing manager of test and measurement specialist Starrett

01 John Cove, marketing manager, Starrett

02 Graphene has a huge array of future possibilities







Enhance your career

with our Advanced Vehicle Engineering courses

- Mechatronics Modelling for Automotive Systems 30 January
- Advanced Control and Optimisation 13 February
- Implementation of Automotive Control Systems 27 February
- Applied Automotive Control 13 March

For more information visit: www.cranfield.ac.uk/transportsystems/cpd

Or speak to a course advisor. +44 (0)1234 754189



See warning Hear warning Speak warning WERMA The wise choice Safety is at the heart of every WERMA product. Through the combination of German engineering, technology and attention to detail. WERMA signal devices help protect you, your customers and your business. Our innovative signal devices alert you and your employees to machine malfunction or danger in a host of different ways by using both optical and acoustic signals transmitted by light, sound or wireless technology. For more information check out our website at: www.werma.co.uk WERMA SIGNALTECHNIK WERMA (UK) Ltd. s@werma.co.uk email: uksak

Made in Germany

Shop online at: www.werma.co.uk

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

3D PRINTING | CNC MACHINING | INJECTION MOULDING

won't lose valuable development time. Get 1 to 200+ parts in 3 days or less.



Order online anytime | Free design analysis



Fay Meadows Senior Customer Service Representative

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

Muscling in on the mainstream

Advances in technology are driving a rapidly growing market for 3D printing. Jason Ford reports

> n December 2014 the editorial team at *The Engineer* were as excited as the rest of the nation about the prospect of being able to build objects with additive or 3D-printing machines.

The team had taken delivery of a CEL Robox micro-manufacturing machine; a 3D printer priced under £1,000 that had entered a consumer market estimated by CEL's calculations to be worth a potential £2.9bn in the UK alone.

The emergence of 3D printing for the consumer market was made possible when the patent for fused deposition modelling (FDM) expired in 2009, bringing machines that would normally cost over US\$10,000 to below US\$1,000, and consequently putting the technology within reach of the burgeoning army of 'makers' that were keen to adopt the technology.

Within the industrial sphere, 3D printing has long been an established method of prototyping and taking designs through multiple iterations. However, in 2014 PwC asked 100 companies how they were using 3D printing, with 29 per cent saying that it was being used experimentally to see how it could be applied. A quarter said they were using the process for prototyping, and 10 per cent said they were using additive for prototyping and production.

The term 'additive manufacturing' has since found a place in the industrial lexicon and gained a certain ubiquity that conjures up images of mass-produced parts and products. Market research company Canalys estimates the global market for 3D printers and services to have grown from US\$2.5bn in 2013 to US\$16.2bn in 2018 but, according to PwC, the technology has not been capable

01 Rear view of the Stratasys Infinite Build Demonstrator

"When you can convert jigs and fixtures into a thermoplastic material you can produce them on demand. Literally overnight"

Richard Garrity, Stratasys Americas

enough or cost-effective enough for most end-product or high-volume manufacturing.

While this situation is unlikely to change radically in the short term, additive has gained enough traction for companies to make serious investments in the technology, including GE, which earlier in the year made a combined bid of US\$1.4bn for Sweden's Arcam and Germany's SLM Solutions Group. The deal for the latter fell through but was superseded by the acquisition of a majority stake in Germany's Concept Laser, a designer and manufacturer of powder bed-based laser additive manufacturing machines, for US\$599m.

Similarly, Siemens recently purchased Materials Solutions Ltd, a Worcester-based company that uses selective laser melting (SLM) to manufacture high-performance metal parts. At the time of the acquisition in August 2016, Willi Meixner, CEO of Siemens Power and Gas division, said the acquired company's strength was turning models into high-quality components in record time. For Siemens, the technology is moving the company away from rapid prototyping into serial production, marking a shift that will see the company industrialise and commercialise additive technology.

Likewise, GE plans to grow its additive business by US\$1bn by 2020, but expects to compliment this with estimated cost reductions of US\$3-5bn over the next decade via additive technology. Speaking in September this year, Jeff Immelt, chairman and CEO of GE, said additive manufacturing would be the key driver to transition the manufacturing giant into a digital industrial company. David Joyce, president and CEO of GE Aviation added that newly

> acquired Concept Laser is a "true pioneer in metal laser melting technology" and that the development of more productive machines will allow the company to offer additive manufacturing as a service for its customers.

Certain estimates value the global 3D-printing metals market at US\$777m by 2020 but the fact remains that FDM with thermosplastics is still dominant and used in over 90 per cent of industrial 3D printers.

This is the view of Scott Crump, the inventor of FDM who went onto co-found Stratasys, the Minneapolisbased company synonymous with 3D printing. Crump was speaking before journalists and analysts at Stratasys HQ in Eden Prairie prior to the launch of two concepts designed to transform the way in which thermoplastics and composites are formed and utilised.

The Infinite-Build 3D Demonstrator and Robotic Composite 3D Demonstrator were being previewed prior to the International Manufacturing Technology Show, which was held in September in Chicago. >>





>> Common to the Infinite-Build 3D Demonstrator and Robotic Composite 3D Demonstrator 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 required for composite extrusion.

The Infinite-Build 3D Demonstrator is designed to address the 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 for an approach to building parts that prints on a vertical plane to produce items measured in feet rather than inches. According to Richard Garrity, president of Stratasys Americas, the system produces parts 10 times more quickly than other FDM technologies.

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

03/04

02 The Infinite Build Demonstrator makes parts measured in feet

03/04 Burner head made for Siemens and Robotic Composite Demonstrator

composite parts in 3D. Garrity added that the traditional composite process can be difficult in terms of scaling, and rendering the types of detail 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 material placement for strength while also

> reducing the need for support structures and eradicating layer transitions. As their designations suggest, both technologies

are at the demonstration phase but input from Boeing and Ford appears to verify Garrity's assertion that Stratasys is evolving toward a more customer-centric approach to business.

He added that Stratasys is targeting key markets where the company thinks additive will be most disruptive, namely aerospace, automotive, and healthcare.

"Our mentality has gone to use-case first," he said. "Traditionally, we've been known as a company that makes great printers but we're very focused now on applications and the use case. We start there, understanding the specific use case [and] understand the problems our customers are trying to solve with regard to the use case, and then working towards a solution."

He added that the company's holistic approach to problem solving is going beyond the supply of printers with broader consideration being given to materials, software, services, consulting and how these can be integrated, in the eyes of the customer, to help them recognise and realise the value of additive manufacturing.

One application of the Infinite Build machine could see the production of aircraft interiors, itself a market said to be worth US\$13.5bn in 2015. But away from production parts, the technology has been identified as being crucial in the design and build of jigs, fixtures, and tooling.

Garrity said: "At Eden Prairie we're using over 1,000 of our own FDM jigs and fixtures. Today's jigs and fixtures are the unsung heroes of the factory floor. They're done traditionally via metal, which [is] heavy and not necessarily customised to a given process or to a given worker, and the lead times often prohibit the use of them, if at all.

"When you can convert jigs and fixtures into a thermoplastic material you can produce them on demand, literally overnight. They are personalised, customised to a given worker or process. That has significant benefits when it comes to safety on the line, so instead of seeing heavy crane lifts you've got thermoplastic parts that can be better managed and used for workers out on the floor."

Dr Ellen Lee, technical leader, additive manufacturing research, Ford Motor Company, said: "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."

For Levin, Stratasys' technology improvements and use of innovative materials are presenting a set of new possibilities for additive, not just by displacing the conventional, but by re-imagining how products can be made and the types of output that can be derived, regardless of the process. (a)



EURO-BEARINGS LTD dB1

CORROSION RESISTANT COMBINED ROLLER BEARINGS and





HEAVY DUTY CORROSION RESISTANT LINEAR MOTION SYSTEM Technical Sales: 01908 511733 Email: sales@euro-bearings.com www.euro-bearings.com/cr

FUJITSU Relays



FUJITSU

Fujitsu high quality relays

Solutions for all your circuit applications. From power and industrial to automotive applications. Offering high voltage loads (DC / PV), wide contact gap. Including EV / PHV and signal relays.

More information: fujitsu.com/components





Achieve toolholding excellence



www.rego-fix.com

Versa <u>move</u> Pallet Handling Systems

MODULES AND MUCH MORE



Compatible with existing systems Versatile use



GESIPA® Threaded Fasteners



This along with our process control tooling, FireFox® C WinTech, also provides a failsafe and a secure joint in serial production of safety critical components.

The experts in riveting technologies

GESIPA Blind Riveting Systems Ltd Dalton Lane, Keighley West Yorkshire BD21 4JU A company at the SES Group T + 44 (0) 1535 212200 F + 44 (0) 1535 212232 info@gesipa.co.uk www.gesipa.co.uk





ATA ENGINEERING PROCESSES LTD

AEROSPACE TOOLING ROUTER CUTTERS WOODWORKING MACHINERY CNC ROUTERS

isel Germany AG

The isel CNC machines in the EuroMod and FlatCom ranges are CNC machines which use the proven rack construction method, built on a modular basis from isel special aluminium profiles.

All linear axes are also from the isel product range and run on polished precision steel shafts with patented linear ball bearings. The drives we use are backlash-free ball screws with hardened and polished ball screw spindles, thread pitches are matched to the intended application. Our linear axes are driven by maintenance-friendly drive modules with servo motors.

The machine table, made of face milled precision T-slot profiles, offers optimal clamping options for a wide variety of workpiece holding fixtures and devices.



made by **isel**°

ATA Engineering Processes Ltd ATA House, Unit B, Boundary Way, Hemel Hempstead, Herts, HP2 7SS t: 01442 264411 e: sales@ataeng.com www.ataeng.com

Copper mine seeks a closer view of logistical operations

Software helps with the convergence of informational and operational technologies. Supplier: ABB



KUKA

The world's third-biggest copper mine is upgrading the ABB software it uses to oversee the product and logistics processes underpinning its operations.

Collahuasi copper mine on Chile's Andean Plateau is one of the planet's largest copper deposits in terms of mineral resources (9,978 million tons). Like many other sectors, mining is seeing a convergence of information and operational technologies, with previously analogue and manual processes now merging with digital elements. While this generally helps companies better understand their asset base, it also adds complexity.

To help manage that complexity and deliver insight across the enterprise, Collahuasi's parent company CMDIC uses ABB's Ellipse, MineMarket and Fieldreach software to oversee its assets. According to CMDIC, the solutions can help improve planning, productivity and safety.

"The mining industry is experiencing challenging times, making it imperative for mining companies to enhance operational efficiencies wherever we can," said Francisco Carvajal, executive vice-president of operations at CMDIC.

"ABB's Ellipse, MineMarket and Fieldreach solutions give us a more holistic view of the condition of our assets, enabling our Asset Lifecycle Management initiative to expedite business processes and drive quality across the value chain."

CMDIC has been an ABB customer for more than 15 years, and has also supplied it with complete electrification systems, including transformers, gearless mill drives and conveyor drive systems all running on ABB's 800xA distributed control system. According to Massimo Danieli, ABB's managing director of grid automation, this deal demonstrates its evolving capabilities in connected industry and IoT.

"With increasingly valuable data flowing from connected equipment and devices to operational systems in real time, this upgrade will provide enhanced visibility across the enterprise to further optimise operations," he said.

Effective work in confined spaces

Mini robotic cell leads to increased productivity gains. Supplier: Kuka Robotics

A mini robotic cell developed by integrator Paul von der Bank is in operation at Brüninghaus & Drissner in Hilden, Germany, leading to increased productivity gains. In the confined space of this so-called Welding To Go (WTG) 1200 cell, a Kuka KR 6 R700 sixx robot from the Agilus series is performing welding tasks. "With the same dimensions as a Euro pallet - 1,200 x 800mm - the WTG 1200 is the smallest robotic cell on the market for arc welding," said Cornelia Hornemann, who is responsible for product launch, project management and production planning at Paul von der Bank.

Furthermore, depending on the specific requirements of the customer, the optimum small robot from the KR Agilus series can be operated in the cell.

The robots of the KR Agilus series are designed for

particularly high working speeds. The KR 6 R700 sixx integrated into the mini robotic cell at Brüninghaus & Drissner, for example, has a maximum payload capacity of 6kg and a reach of approximately 706mm.

The sliding doors of the WTG 1200 can optionally be opened either automatically or manually before a worker loads the workpieces into the welding fixture. Once the door has closed, the robot starts welding.

"At our plant, the WTG 1200 works reliably in three-shift operation," said Markus Nickolai, head of production at Brüninghaus & Drissner.

The mini robotic cell is said to have resulted in productivity gains of up to 50 per cent, as the operator is now able to prepare the next workpieces while automatic production is in progress.

Thanks to the repeatability of the small robot, the quality of the weld seams has also improved noticeably. Paul von der Bank is already working on the next mini-cell generation with Kuka robots for its customers.

The WTG 1500 will then have an external axis for turning the welding fixture. $\ensuremath{\textcircled{}}$

54 THE ENGINEER | NOVEMBER 2016

Encoder optimises operation of wafer-transfer robots

Wafers are valuable and break easily so stability and reliability are crucial. Supplier: Renishaw

A wafer becomes multiple IC units in a series of complicated processes, where wafers rely on a wafer-transfer robot to perform fast and accurate transfers between process stations. Wafers are valuable and break easily, so stability and reliability are critical for the robot's effectiveness.

Korean-based robot manufacturer Robot and Design (RND) uses an RLS LM10 series incremental magnetic encoder system – from Renishaw associate company RLS – to optimise the performance of its wafer-transfer robots.

After silicon passes through a number of upstream processes, such as cutting lithography and etching exposure deposition, it becomes a disc-shaped wafer with a 'printed circuit' on the surface. The wafer then passes through a number of downstream processes, including bonding, wiring, packaging and testing, to finally become multiple units of powerful miniature ICs.

Wafers can be manufactured at the nanometre level but this level of thinness can lead to damage during transfers, and also necessitates the wafer surface being dirt-free throughout the whole process. Most manufacturers are now using robots instead of humans for wafer transfer, one of the important operations in semiconductor manufacturing.

RND's wafer-transfer robot operates at velocities up to 1.8m/s. It relies heavily on a highly responsive, reliable and stable position feedback system. Any small position errors can cause wafers to crash, resulting in a very costly economic loss.

RND's general manager Hyun-Gug Jung said: "Generally speaking, compared to other semiconductor equipment, the accuracy requirement for the encoder on a wafer-transfer robot is relatively low. The accuracy is important, but stability is our top priority. When researching the market for encoders as one of the robot's core components, repeatability is always a primary concern. The LM10 series magnetic encoder offers repeatability up to the unit of resolution." (a)

Keeping well on track with award winners

Linear motor track system picks up two prizes at PPMA event. Supplier: Siemens and Festo

An Industry 4.0-ready linear motor track system, developed jointly by Siemens and Festo, has picked up two Processing & Packaging Machinery Trade Association (PPMA) Awards.

The Multi-Carrier-System (MCS) took home the prizes for Most Innovative Automation System and Partnership of the Year. Potential applications for the system include cosmetics packaging with its huge number of product variants, food and beverage processing with quick seasonal changes or the industrial manufacturing of bespoke products.

"We are delighted to work with Festo, which is without doubt a market leader in industrial automation," said Keith Thornhill, business manager for food and beverage at Siemens. "This award-winning partnership will increase efficiency and create real value for customers across the UK. The Multi-Carrier-System is a concrete example of Industry 4.0 being realised – radically boosting flexibility in complex manufacturing and production environments."

Incorporating decentralised sensors and intelligence, MCS's flexible electromechanical design enables adaptable, reconfigurable and economic production, while its OPC-UA interface enables integration into Industry 4.0 host environments. Motion profiles can be defined for each carrier, enabling them to move freely and independently of all other carriers. They can be started and stopped at any desired position and moved towards each other without risk of collision, as well as grouped together and moved synchronously at fixed distances.

"This award-winning collaboration between two industrial automation leaders has resulted in an innovative and versatile transport system for manufacturing and production that delivers flexibility and modularity for machine builders that have to manage large product diversity," said Steve Sands, product manager at Festo.

"We are delighted the judges of the prestigious PPMA Group Industry Awards 2016 have recognised MCS, Festo and Siemens with two awards, Most Innovative Automation System and Partnership of the Year, citing the innovation, flexibility and impact MCS offers machine builders, deeming it 'excellent engineering' and 'well integrated'."





Discover how we helped a car parts company stay on track

Agility is a flexible, dynamic asset and maintenance management platform that maximises uptime and minimises production disruption. Identifying the causes of repetitive maintenance and downtime is essential to reliable production.

Agility is delivered and fully supported by SoftSols, a global manufacturing solutions provider, so you have the reassurance of a technology you can trust and rely on.

agility

The result is efficient working, increased productivity and a business working at full speed.

Take a look at our case studies to discover Agility in action at www.softsolsgroup.com or call us on 01924 200344 today.





Making cars, faster

Automotive manufacturers all over the world take advantage of REVO® 5-axis measurement systems to achieve up to 70% cycle time savings on their CMMs.

REVO[®] – a measurement revolution

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

Your global trusted partner in bolt optimization



The Nord-Lock Group is a world leader in bolt securing systems. We offer a unique combination of bolting expertise and a wide product range, including Nord-Lock wedge-locking solutions, Superbolt multi-jackbolt tensioners, Boltight hydraulic tensioners and Expander pivot pins.

Our mission is to safeguard human lives and customer investments by securing the world's most demanding applications.

www.nord-lock.com

Nord-Lock Ltd Tel +44 (0)1264 355557 • Fax +44 (0)1264 369555 • enquiries@nord-lock.co.uk





HINGES FOR EVERY APPLICATION

BESPOKE AND STOCK HINGES FROM THE UK'S NO1 SPECIALIST MANUFACTURER





Bearings help turntable maker stay in the precision groove

Self-lubricating and dry-running bearings meet stringent requirements. Supplier: Igus



The recent upsurge in the popularity of vinyl posed an interesting challenge for turntable manufacturer Rega. The Southend-based company had for many years been sourcing metal ball bearings for its high-end equipment from the Far East, but increased demand was putting pressure on this supply chain.

In search of a solution, and perennially looking for marginal gains in his turntables, Rega owner Roy Gandy contacted Igus. Together the companies explored the possibility of using Igus's Xiros tribopolymer ball bearings, which are self-lubricating and dry running, making them maintenance-free and impervious to contamination.

"Our turntables and tone arms have to be more accurate than the equipment used to press vinyl," said Roy Gandy, owner of Rega. "We think of the turntable not only as a means of playback, but as a precision measuring device that has to track and interpret the groove in each piece of vinyl it reads. The Xiros bearings are critical in helping us achieve this ambition and we have enjoyed working hand in hand with the talented Igus engineers to make this happen."

Following 18 months of development, prototyping and testing, the team successfully produced a bespoke Xiros bearing that met the stringent requirements and expectations Rega had for producing a perfectly balanced, friction-free tone arm with no drag. It features a total of four Igus Xiros bearings: two on its vertical axis and a further two on its horizontal axis.

According to Igus, the bearings produced for Rega are among the lowest friction bearings it has ever made, and compare favourably with the original metal bearings in terms of noise, vibration and acoustics, as well as delivering improved precision and lead times. The Xiros bearings feature in two of Rega's top-selling turntables, and are also being evaluated for use in other tone arms and turntables across the range. ©

Getting a good handle on a quality package

Handling and vision inspection to sort 'corneal scaffolds'. Supplier: LG Motion

Oxford MEStar, a bioengineering spin-out from Oxford University, approached LG Motion to design and manufacture an integrated handling and vision inspection system to quality check and sort specially packaged 'corneal scatfolds'.

A challenge was the detection of translucent corneas and scatfolds in a similarly transparent package.

The corneal items are suspended in a petri-dish solution, making it difficult to determine their exact position to the packaging. LG Motion worked with Scorpion Vision to develop a camera vision system, with the end solution able to evaluate the appearance and location of the corneal scaffold to within 0.1mm.

The system is mounted on a machine frame built with the MiniTec

aluminium profile system and consists of a bespoke XZ motorised slide assembly with motion controller, vision system, laser analysis unit and control computers.

The motion mechanics – custom stepper driven ballscrew positioning stages with single linear motion guide bearings – are designed to maximise space on the work platform. With a 500 x 50mm travel range, the stages include manual drive wheels to allow the operator to position the axes under power-off conditions to maintain the machine. The motion controller, the Arcus Technology PMX-4, is an advanced micro-stepping unit with fast synchronising inputs and outputs for the coordination of motion and external events required for the application.

To improve the consistency of tests and ease of use for multiple operators, LG Motion provided a graphical user interface front-end program that allowed simple system operation. The HMI touch-screen displays the machine phases – loading the package, automatically locating the cornea and its scaffold, the laser inspection phase and pass or fail for acceptance or rejection – and then prompts the technician to load another package. (*)



Powering up for Cybathlon's paraplegic competitors

Many of those taking part take advantage of company's drives and motors. Supplier: Maxon



Swiss motor specialist Maxon had a prominent role at the recent Cybathlon event in Zurich, which saw paraplegics competing with the aid of exoskeletons that were powered by the company's components.

The inaugural Cybathlon games took place in early October, organised by the world-renowned ETH Zurich (Swiss Federal Institute of Technology in Zurich). Acting as both sponsor and partner, Maxon provided an on-site workshop for competitors, many of whom were using the company's drives and motors.

"We spent decades perfecting our motors", said Maxon CEO Eugen Elmiger. "A lot of money has gone into research and development. These days, the motors from Switzerland can be found everywhere, in robots, airplanes, cars, and medical devices." As well as taking on an obstacle course with the aid of exoskeletons, machine-assisted competitors also participated in five other disciplines: prosthetic legs; prosthetic arms; motorised wheelchairs; bicycles with muscle stimulation; and virtual racing using thought control.

In total, almost 70 teams from all over the world took part in the games. It is hoped that the event will continue to grow over the coming years, with advances in technology being incorporated by future competitors. There is also the possibility of new disciplines being introduced as science helps those with disabilities to compete in a wider number of events.

"Our aim with the Cybathlon is to break down barriers between the general public, people with disabilities, and scientists," said games founder Robert Reiner, professor for sensorymotor systems at ETH's Department of Health Sciences and Technology.

This year's event saw Switzerland and lceland tied for top honours, with a mixture of teams taking home three medals apiece for each country. Johnny Beer Timms took silver for the UK in the functional electrical stimulation bike race on behalf of Team BerkelBike. (■

Workpiece pallets get a sense of dynamism

Accumulating pallet recirculation system gets to work in Germany. Supplier: mk profile systems

A manufacturer of white goods in Germany is reaping the benefits of MK Profile Systems' accumulating pallet recirculation system.

The SPU 2040 accumulating pallet recirculation system enables dynamic feeding, buffering, positioning and separating of workpiece pallets (WT). In this application the SPU provided the solution for transporting the housing of dishwashers.

When linking multiple cycle or changeover times, the SPU 2040 allows a countercyclical operation with automatic recirculation of the workpieces. A flat top chain carries the workpieces on the WT to the assembly plant. After removal of the workpieces the empty pallets are carried over the return roller and then conveyed back on the underside of the conveyor. They are then available at the starting point of the conveyor waiting to be loaded with new workpieces. A second conveying level and devices for lifting and lowering with complex control elements are no longer required. No additional manual or automated loading of pallets is necessary either.

In this particular application, the SPU will equalise and buffer each dishwasher housing carrier between two machines through the process of becoming a welded unit and a fully assembled unit. There is also a requirement to stop the carriers for optical inspections via image processing and for mounting further components.

Although the SPU is available as both a single- and dual-lane solution, due to the size of the dishwasher housing (approximately 800 x 600 x 400mm) a double-lane solution was provided. Additionally, the carriers consist of two parts, to ensure navigation around the return roller.

The SPU 2040 is compact in comparison with other systems. It also offers the benefit of favourable ergonomic properties for workers who place or remove dishwasher housings. (•)



INNOVATION IN METROLOGY WE'RE MORE THAN JUST GREAT **PRODUCTS**

WE HAVE ACCUMULATED OVER 150 YEARS OF METROLOGY EXPERTISE info@mahruk.com

YOUR PARTNER IN MODERN METROLOGY

EXPERIENCE

Since developing our first Vernier calipers back in 1868, we've accumulated over 150 years of metrology expertise. Producing the world's first digital indicator and microprocessor controlled roughness measuring instrument. We now hold over 10,000 different products and we continue to drive the leading edge of innovation in modern metrology.

Ma

Our highly trained team operates from 52 countries across the globe.Driving metrology research and high quality production whilst supporting our valued customers

PRECISION Our trusted measuring instruments feature in all manner of prominent processes from automotive and aerospace manufacturing to bio mechanical research and

mechanical engineering

We aim to ensure the quality of every product manufactured, every service undertaken and every procedure implemented in order to satisfy our customer needs. Many of the Mahr group companies have certified quality management systems that comply with DIN EN ISO 9001:2008. Wherever precise measurement is required there is a Mahr tool for

QUALITY

WWW.MAHRUK.COM

01908 563 700



MAHR UK PLC 19 Drakes Mews, Crownhill Milton Keynes MK8 0ER Tel: 01908 563700, or visit website www.mahruk.com to learn more a about Mahr products and service

Technical Training Solutions Providing Practical Engineering Skills Training For Industry



Longest cable guarantee in the industry



... number one in moving cables



















Widest selection. 36 Month Guarantee. Unmatched Testing.



Reduce downtime with chainflex

- Up to 36 months of guaranteed reliability
- Up to 10 million cycles of
 - guaranteed cable performance
- Calculate lifetime and order online





Getting down with the supply chain

Working in the car industry isn't just about OEMs. There are thousands of exciting opportunities in the wider supply chain. Evelyn Adams reports

01/02/03 Some

businesses are changing their recruitment requirements with roles opening up to those wishing to transfer their skills from another sector



ritain's automotive supply chain received a welcome boost last month with Nissan's announcement that it was to build new models in the UK. The firm, which is the UK's largest car manufacturer, committed to building its new Qashqai and X-Trail SUV at its Sunderland plant. Post-Brexit, the move

provides some much-needed confidence to British car manufacturers. Around 28,000 supply-chain jobs in the UK are currently supported by Nissan, among a wider 78,000 dependent on British-based vehicle manufacturers. If other manufacturers follow Nissan's lead, then growth in the supply chain will continue, creating career opportunities for engineers at all levels.

"We are a key supplier to Nissan in the UK and globally, with 1,400 staff in the north east alone, so the decision to build two new models in Sunderland is excellent news," said John Barnett, vice-president manufacturing and supply chain for Calsonic Kansei, which supplies a variety of automotive components for car manufacturers worldwide. "A significant proportion of the components used to manufacture cars at the plant originate from us. In future, the opportunities are now there for us to win even more business."

There is currently an estimated £6bn opportunity for component manufacturers, according to the Society of

Motor Manufacturers and Traders (SMMT). Billions of pounds have already been invested in domestic supply-chain networks to fulfil production needs and cut the cost of logistics. This investment is having an impact, with the car industry being one of the UK's biggest manufacturing success stories. Over the past five years, the number of British-built cars has risen from 36 per cent to 41 per cent with the potential to reach 50 per cent in the near future.

Experts believe that trend will continue. But the sheer rate of





the industry's recent growth has resulted in a skills shortage. The Automotive Council said that up to 5,000 vacancies currently exist in UK automotive manufacturing. Two in five respondents to a recent SMMT supply-chain member survey said that the availability of skilled workers, apprentices and graduates could impede their company's growth over the next three years

"Automotive engineers – from blue- to white-collar roles – are in high demand across the sector," said Les Hewlett, head of automotive at recruitment firm, Matchtech. "The full impact of Brexit remains unknown; however, a study conducted last year by the SMMT projected that the UK alone will benefit from 320,000 new jobs by 2030 with the development of connected and driverless cars. We are therefore confident that it will have a limited effect, although the roles will change. But to support that growth, the industry needs to attract the right talent."

The top two most critical roles needed in the automotive supply chain are design and production engineers. Skills in lean manufacturing, advanced problem solving and tool making are also in high demand. But the roles are ever changing and, looking to the future, engineers with skills across the board will be needed. "It is also a very exciting time to be starting a career in the automotive industry; the rise of the connected car means we are expecting more change to the cars we drive over the next 10 years than we have in the last 100," said Hewlett.

"Skills are in short supply so we don't expect this to set wages back"

Les Hewlett, Matchtech

With the skills shortage are constant concern, some businesses are changing their recruitment requirements with roles opening up to those wishing to transfer their skills from another sector. "There are lots of opportunities for engineers in the UK's automotive supply chain - and we support all entry routes," said Tamzen Isacsson, SMMT director of communications and international. "Transferring from another sector such as rail, marine, aerospace or energy is perfectly possible as there are plenty of synergies. SMMT has hosted events to bring skills and knowledge that exists in other sectors into automotive. We are very keen to continue this, and welcome companies and skilled staff from other industries looking to work into automotive - diversification is key."

Hewlett said: "Skills are in short supply though so we don't expect this to set wages back negatively. More specifically, we have witnessed skill-set spikes; electrical design for example has seen a 14 per cent hike



in contract hourly rates in the past 12 months, which happened almost overnight."

Working for a small engineering firm has some major advantages. SMEs are often the ones driving innovation and can get their ideas to market faster without being bound by rigid hierarchical structures. Smaller teams that are more flexible in terms of change value creativity.

SMEs also offer great opportunity to progress rapidly through the ranks, and many benefit from being able to provide one-on-one contact with senior-level engineers who can act as mentors to new recruits.

The divide between leadership and those on the ground floor is also usually smaller, allowing management to get a more realistic understanding of what everyone's role involves. (a)



Career Opportunities – Wisconsin, USA Take Charge: Put Your Career in Your Own Hands

Due to our increasing drive in the global power generation market we need to increase our engineering capacity and offer a range of engineering positions which offer great career and lifestyle opportunities.

We are seeking engineers with skills and proven experience in the following areas:

- Emmissions (Diesel & petrol compliance to EPA and Euro)
- Compliance (CE, Rohs, Reach)
- Thermal/Heat Transfer analysis (CAE)
- Hydraulic –System design & development (Easy 5)
- Polymer Technology (structural and moulding non-linear analysis and product design)
- Engineering systems (PLM, PDM, SAP Interface, CAD, CAE)
- Electronics/Controls/Electrical Harness Design/Remote Monitoring (Software and Firmware code development, PCB Architecture, Hardware in loop testing)
- Virtual Engineering (Structural and acoustic analysis)
- LED Technology
- Project Management

We are seeking people with and without management experience but have the passion to progress within our business. An Engineering Degree backed up with at least 5 years' experience is essential.

We provide excellent salary and benefits packages with full relocation, transition and support assistance

About the Company

Founded in 1959, now with 4 vertically integrated manufacturing facilities in North America, Generac manufactures the widest range of power products in the marketplace including portable, residential, commercial and industrial generators. We are also the leading designer and manufacturer of manual and fully automatic transfer switches and accessories for backup power applications up to 2 MW.

About the Location

Located in the mid-west region of North America, close to the City of Milwaukee, these career opportunities offer a lifestyle, close to the Great Lakes where beautiful rural living locations, great outdoor life, superb sports and leisure activities and endless entertainment and social activities are a way of life.

To apply or obtain further information about these exiting opportunities please email your CV to David Bramhill at david.bramhill@generac.com

Rail experts wanted

Balfour Beatty is a leading provider of rail infrastructure. Our expertise covers electrification, track, power, civils, specialist rail plant, railway systems and technologies.

We have opportunities for talented people across the UK, including:

- Project Engineer, Thameslink project
- Senior Delivery Engineer, Thameslink project
- Assistant Engineer, Engineering Technology Solutions, Liverpool
- Senior Engineer, Engineering Technology Solutions, Liverpool

To find out more and apply visit **balfourbeatty.com/careers**



Fast and precise component workholding?

The answer MES



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





Nov

from the archive | torpedos

War and peace **1905**

The inventor of the torpedo paradoxically considered it as a means of ensuring peace rather than war



bituaries in archive editions of The Engineer always make interesting reading; with our benefit of hindsight we often have a different view than contemporaries of the deceased. An interesting case in

point is the obituary of Robert Whitehead, a name now perhaps little known but significant because he was the inventor of the torpedo: this autonomous weapon was the forerunner of the UAVs that are now such a controversial feature of warfare.

"Paradoxical as it may seem, Mr Whitehead is reported to have considered [the torpedo] as a means for ensuring peace rather than bringing war," the obituary said. "His idea, no doubt, was of the fearful effects of the torpedo, once realised, would be a sufficient deterrent to peoples and nations contemplating war." History, of course, repeats itself and we can only imagine the conversation Whitehead might have had with proponents of deterrence theory in the 20th century and beyond.

Even in his lifetime, Whitehead was proved wrong; the obituary noted that he had been too ill in the last year of his life to have taken much notice of the conduct of the Russo-Japanese war of 1905. Both sides possessed torpedo technology, but this did nothing to prevent them from opening hostilities, and, over the course of the war, both sides launched a total of nearly 300 torpedoes and one of the Russian flagships - the battleship Knyaz Suvorov - was the first modern ship to be sunk by a torpedo. Both sides possessed large numbers of torpedo boats, many of which had been built in Britain.

Moreover, in this conflict the Imperial Russian Navy was the first navy in history to possess an independent operational submarine fleet. Whitehead's obituary said that without the torpedo the submarine "would have no raison d'être". It is safe to say, it added, that Whitehead had probably had more influence than anyone else on modern naval tactics.

Although torpedoes had existed for some time

before Whitehead, it was he who developed the first self-propelled and self-steering torpedo. This happened in Austria, where Whitehead spent most of his working life; the invention was achieved with what The Engineer seemed to regard as remarkable speed. A Captain Luppis of the Austrian Navy approached Whitehead in 1866 with a model of a torpedo - a small boat propelled by clockwork that was supposed to be steered from the shore and carried a percussion explosive in its nose. In less



"His idea, no doubt, was the fearful effects of the torpedo would be a sufficient deterrent to peoples and nations contemplating war"

The Engineer

Robert Whitehead and his son with a battered test torpedo circa 1875 than a year, Whitehead had developed his first prototype. The first successful prototype was developed in 1868, and the Austrian Navy adopted the technology the following year, with Britain following suit in 1871. At that time, the torpedo could travel at a speed of eight knots for about 600 yards. By Whitehead's death, the range had improved to more than 4,000 yards, the speed to 36 knots, and the weight of explosive carried had increased from 30lb to about 200lb.

According to The Engineer, the gyroscopic steering mechanism of the then-current torpedo was developed by a Mr L Obry of Trieste. "This is based upon the principle that a body revolving on a free axis tends to preserve its plane of rotation," it explained. "A gyroscope with a plane of rotation parallel to the vertical axis of the torpedo will have an angular motion if the torpedo is diverted from its original course. This angular motion is employed to actuate the steering mechanism by operating an air motor connected with the rudders, and keeping the torpedo in the line of discharge."

The gyroscope was in fact clockwork, having a flywheel rotated by a spring, which was wound up with a key on the outside of the torpedo and kept in tension until launch.

Whitehead did not come from an engineering background. He was born in Bolton, in a family that was, like many in the region, employed in the cotton industry. At 14, however, he was apprenticed to his uncle, William Swift, who was the manager of a Manchester engineering works. Showing early aptitude as a draughtsman, he moved to Marseille with his uncle, but soon left and set up business on his own in Milan, where he was mostly involved in the silk-weaving industry. Moving to Trieste in 1948, he opened his own engineering works where he built engines for the Austrian Navy.

It seems that Whitehead was a pleasant man, "much loved for his courtesy and benevolence", according to the obituary. "There is reason to believe he felt acutely that, though honoured by other countries, the country of his birth did not regard him in the same manner," but "he was the most modest and retiring of men, and did not seek public fame for himself." He died at the age of 83. SN .

digest

Word oftheissue

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

English first records 'rivet' around the end of the 14th century. Derived from Old French rivet it originally referred not only to 'rivet' but also to a 'nail' – this makes sense, as both are ostensibly the same thing. The French derived rivet from river, meaning 'to clench, fix, fasten' and related to Middle Dutch wriven 'turn, grind'. However, we can trace this back much further to the same root as 'rive' meaning 'tear into pieces, strike asunder'. This usage came to English with the Scandinavian languages – Danish rive, meaning 'scratch, tear'. This can be traced to Proto-Indo-European root rie, also meaning 'to scratch, tear or cut'. This early root has also produced seemingly unrelated terms. Although when we think of Greek ereipia 'ruins', Middle German rif 'riverbank', Danish rift 'breach', each refers to some sort of break – and without a break there is no need for the rivet.

Bigpicture

Rolls-Royce's UltraFan engine concept has reached a significant milestone with the first run of the system's gearbox. The test, which took place at the company's facility in Dahlewitz, Germany, marks the start of a series of tests that will see the gearbox reach up to 100,000hp.





Prizecrossword

When completed rearrange the highlighted squares to spell a rotating part in a motor. The first correct answer received will win a £20 Amazon voucher. Email your answer to **jon.excell@centaur.co.uk**

Across

- 1 One piece of kitchen furniture (4)
- 3 Company that hires only union
- members (6,4) 9 Element used in alloys with platinum (7)
- 11 Alloy of mercury with another metal (7)
- 12 Conflict between social or economic groups (5,8)
- 14 Final point in a process (9)
- 16 Secure with ropes (3-2)
- 17 Make a strenuous effort (5)
- 19 Empties completely (6,3)
- 21 Assign too low a value to (13)
- 24 Staying power (7)
- 25 Ascribes an achievement to (7)
- 26 Power of creative imagination (10)
- 27 Government tax (4)

Down

- 1 Being performed live (10)
- 2 Pressure lines on a weather map (7)
- 4 To restrict or confine (5)
- 5 Small carved or moulded figure (9)
- 6 Heavy pulling machine (7,6)
- 7 Condition promoting sanitary practices (7)
- 8 Flow intermittently (4)
- 10 Coated electrical cable (9,4)
- 13 In a spick-and-span manner (10)
- 15 Establish after a calculation (9)
- 18 Create by training and teaching (7)
- 20 Having a play of lustrous colours (7)
- 22 Draws something in with a vacuum (5)
- $23 \hspace{0.1 cm} \text{One-thousandth of a second (4)} \\$

Last issue's highlighted solution was resonance. Winner: Mike Simpson

SOUTHERNManufacturingManufacturing& Electronics

FIVE | Farnborough | Hants | GU14 6XL

21st – 23rd March 2017 9.30am – 4.30pm (3.30pm close Thurs)

The UK's top Manufacturing and Industrial Technology Exhibition

Meet over 800 national and international suppliers under one roof in Farnborough this March at Southern Manufacturing & Electronics (inc AutoAero) 2017.

See live demonstrations and new product launches of machine tools & tooling, electronics, factory & process automation, packaging & handling, labelling & marking, 3D printing, test & measurement, materials & adhesives, rapid prototyping, ICT, drives & controls and laboratory equipment.

Free industry seminar programme online @ www.industrysouth.co.uk

The exhibition is **free** to attend, **free** to park and easy to get to. Doors open at 9.30am on Tuesday 21st March.

AUTOAFPO

RINE Autosport Aerospace Aedical Electronics ackaging

> Automation & Robotics

>>>

Pre-register online now for your free entry badge and show preview at www.industrysouth.co.uk

SOUTHERN MANUFACTURING & ELECTRONICS is an ETES event organised by European Trade & Exhibition Services Ltd

Tel 01784 880890 · email philv@etes.co.uk



Register here with your smartphone





Helping our clients achieve success through great product design

www.dca-design.com