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Pain relief

Behind the scenes at one of the UK's most nimble medical innovators



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Game changer

BAE Systems' UK Sport lead Henry White on engineering Olympic success



Car of the issue

Tesla's Model X – taking a big step towards the driverless dream



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HMI drives forward

his publication has remarked before on the increasing convergence of the automotive and consumer electronics sectors. And nowhere was this more evident than at last month's CES, the global consumer technology trade show that takes place every year in Las Vegas.

Vehicle manufacturers and automotive suppliers have been steadily growing in numbers at CES in recent years. but there were so many at this year's event that one commentator joked it should be renamed the 'Car Electronics Show'

Unsurprisingly, there was a heavy emphasis on electric powertrains and autonomy at the show - the twin forces propelling profound and rapid change in the sector.

But, perhaps more interestingly, there was plenty of evidence at the show of the electronics and automotive sectors working closely together on the development of the advanced human machine interfaces (HMIs) that we will use to interact with the vehicles of tomorrow.

In this issue's cover story (p22) we take a look at the trends that are driving the development of HMI technology and examine some of the fascinating control and display technologies that could be coming to a car near you soon.

"The Tesla Model X and its Autopilot provides an intriguing glimpse of where our cars are heading"

Staying on the automotive theme, our new regular car of the issue feature this month (p32) takes a look at The Tesla Model X, and puts its much-vaunted Autopilot system through its paces. As we report, although the system's hardware is ready to support full autonomy, the car's current driverless capabilities are constrained by legislation. Nevertheless, Tesla's lack of emotional baggage in the automotive space means that it's been able to design the autonomy-ready car from the ground up in a way that perhaps doesn't come naturally to more established carmakers, and - like the technologies featured in our cover story - the car provides an intriguing glimpse of where our personal vehicles are heading.

Looking even further into the future, resident scifi writer Jon Wallace wonders whether the flying car will ever take off (p31) and asks whether its potential to render national borders meaningless will stifle the technology before it's born.

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MEDICAL

Guiding surgeons along the spine

System combines camera images from outside of patient with 3D X-rays Helen KNIGHT REPORTS

n augmented reality system designed to guide surgeons through delicate minimally invasive spinal procedures

has been developed by Philips.

The system, which combines camera images of the outside of the patient with three-dimensional X-rays of the inside of the body, is designed to create a detailed path for the spinal surgeon to follow. This could help to improve surgical tool navigation and implant accuracy, as well as reducing procedure times.

Spinal procedures have traditionally been carried out using open surgery, in which a large incision is made in the body and the muscles moved aside in order to expose the vertebrae. But this invasive procedure results in a lengthy recovery period and a considerable amount of pain for the patient, according to Ronald Tabaksblat, business leader of image-guided therapy systems at Philips.

However, replacing open surgery with minimally invasive techniques is particularly difficult in the case of spinal procedures such as vertebrae fusion, as screws are inserted which must be positioned with sub-millimetre accuracy, said Tabaksblat.

"A small error in one direction and you could hit an artery, causing major bleeding, while a small error in another direction means you could hit a nerve, causing nerve damage or even paralysis," he added.

"This technology is designed to offer the ability to carry out a procedure with a high level of confidence and accuracy, using minimally invasive techniques."

The system could help to improve surgical tool navigation



The system uses high-resolution optical cameras mounted on a flat-panel X-ray detector to image the surface of the patient. It then combines the external view captured by the cameras with the 3D internal view acquired by the X-ray system to create accurate real-time, augmentedreality images of the patient's anatomy.

"We can make 3D acquisitions of the vertebrae of the spine, and show where they lie in the body, and we can also register what happens above the skin," said Tabaksblat. "So now if the surgeon holds an instrument above the skin, we can show them a virtual path along which the instrument should be inserted into the body."

Small patches stuck onto the patient's skin are used as landmarks by the software, to ensure it knows exactly where the cameras are pointing in relation to the position of the body at any given time. This also allows it to align the external images with the X-rays of the internal anatomy, and combine the two.

The system generates different 3D views of the patient, from above and to the side, allowing the surgeon to align their instruments accurately before insertion.

The system has undergone pre-clinical trials in an experimental setting at Karolinska University Hospital in Stockholm, Sweden, and the

Cincinnati Children's Hospital Medical Center in the US. In the trials, which were recently published in the journal *Spine*, the technology was shown to improve the overall accuracy of screw placement from 64 to 84 per cent.

The technology will now undergo clinical trials at 10 hospitals around the world. These will determine whether the system can continue to improve the accuracy of spinal surgery when carried out in a clinical setting.

The company is also currently investigating the application of the technology in some types of trauma and brain surgery.

Cranial surgery is particularly challenging, as the instant the skull is opened the pressure in the brain is reduced, altering its shape, said Tabaksblat.

"This means any preacquired images are pretty much useless once you start operating, so there are significant unmet clinical needs in this area," he said. ®

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Aerospace

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Automotive

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BIOTECHNOLOGY

New bioprocess feeds the planet

Process produces mycoprotein more cheaply and without waste ANDREW WADE REPORTS



The new process has been integrated into a biorefinery

UK company has developed a new biotechnology process that is able to produce mycoprotein – the main ingredient in

Quorn – cheaper than ever before and with zero waste.

3f bio is a technology spin-out from Strathclyde University. Its technique involves integrating the production of bioethanol with the fermentation of mycoprotein. The current method for producing mycoprotein uses glucose as a feedstock, whereas 3f bio's process uses a feedstock produced in the bioethanol refinery process. "In the integrated 3f process, by integrating this into a biorefinery, the aim is to access the cheapest source of a sugar feedstock, and we take a sidestream of wheat hydrolysate as the new feedstock," Jim Laird, 3f bio's CEO and commercial director, told *The Engineer*.

"Within the current fermentation process for mycoprotein, there are relatively high costs associated with processing waste that contains unprocessed sugars and proteins. In an integrated process, this 'waste' is fed back into the biorefinery and will be fully processed into either fuel or feed."

That current process is carried out exclusively by Quorn, where Laird

previously worked as international director. The UK company's meat-free products have grown in popularity in recent years, with people embracing alternative sources of protein for a variety of reasons, including the environmental impact of livestock farming, as well as its ethical implications. But the patent for mycoprotein expired in 2010, opening the door for new players to enter the market. 3f bio's new process looks set to capitalise on this, producing mycoprotein at a fraction of the cost of Quorn's process.

"The technology was developed in Strathclyde University, which has extensive experience in this area, and equally driven by the two founders who have extensive industrial experience of large-scale engineering projects and of driving efficiency into large-scale processes," said Laird.

"Following development and exemplification over 2013–14, the patent application was submitted in 2014. Subsequently, 3f bio was established as a spin-out company in 2015 and, after initial funding was secured, the business commenced operation with three employees to progress the feasibility and proof of concept in April 2016."

The company is also an active member of Glasgow's Industrial Biotechnology Innovation Centre (IBioIC), and the first user of its Rapid Bioprocess Prototyping Centre. According to Laird, access to the centre has enabled the technology to develop from the lab to industrial scale at a faster rate.

"It provides the much-needed resources for scale-up facilities," he said, "critical for a start-up not having the capital spend for equipment."

ENERGY

Tidal power is firmly in the energy mix

Swansea Bay project gets go-ahead after review

ANDREW WADE REPORTS

Swansea Bay tidal lagoon is set to go ahead after a government report recommended the technology plays a role in the UK's energy mix.

The review, led by former energy

minister Charles Hendry, comes after plans for the Swansea demonstrator project were put on hold. It advocates the formation of a new Tidal Power Authority to oversee the tender process for large-scale tidal lagoons. Hendry also recommended that a pathfinder project be undertaken before moving to larger lagoons.

Hendry believes the costs of a pathfinder project – likely to be located at Swansea, where Tidal Lagoon Power (TLP) has been developing plans – would be about £0.30 per household per year for the first 30 years. The 16 turbines that will harness the tide in Swansea are 7.5m in diameter and 76m in length. Built by General Electric and Andritz Hydro, their combined output will be 320MW. The technology is designed to last, with the aforementioned plant life expectancy of 120 years.

Using Swansea as proof of concept, TLP's plan is to scale up, first to nearby Cardiff and Newport, then to West Cumbria, Colwyn Bay and Bridgwater Bay.

"While, there are no major underlying concerns over technical viability there are many issues to explore through Swansea Bay, both technical and environmental, and the learning from this project will be essential in shaping future developments and in determining their viability," said Dr Simon Harrison, chair of the IET's Energy Panel. (9)

Newsinbrief

Modular moment A major programme to develop and commercialise small modular reactor (SMR) technology is to begin, with Nuclear AMRC confirming that it is joining Rolls-Royce, AMEC Foster Wheeler, Nuvia and Arup to bring a design proposed by Rolls-Royce to the UK market. Rolls-Royce is proposing the development of a modular reactor capable of producing 220-440MWe depending on its configuration, designed specifically to be built and commissioned in factories.

The Italian Navy job

Rolls-Royce is to supply engines and waterjets for the power and propulsion of two new highspeed vessels designed and built by Intermarine for the Italian Navy. Construction recently began at Intermarine's Sarzana shipyard. The vessels are more than 40m long, 8m wide and powered by three MTU 2000 series diesel engines connecting to three Kamewa S4 water jets.

Racing certainty McLaren Racing and Stratasys have entered into a new four-year partnership under which Stratasys will supply McLaren Racing with 3D printing and additive manufacturing. Stratasys will work with the Grand Prix team as it increases its rapid manufacturing capacity at the McLaren Technology Centre in Woking, UK.

Automotive high

Last year saw a 17-year high in the number of cars built in Britain with 1.7 million cars rolling off production lines. According to SMMT, demand from overseas has helped to drive this increase with more than 1.3 million cars destined for export to over 160 countries. The UK is the second-biggest producer of premium cars after Germany.

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AEROSPACE

UAV takes up a lofty perch

Perched landing could lead to UAVs being able to come down in confined spaces Helen KNIGHT REPORTS

> n unmanned aerial vehicle has carried out a perched landing, controlled by machinelearning algorithm, for the first time.

The achievement, by a team at BMT Defence Services and Bristol University, could lead to the development of efficient, morphingwing UAVs that can land in small or confined spaces, to deliver aid or gather intelligence.

Existing aircraft are either fixed wing, which are very efficient but have limited manoeuvrability, or multi-rotor, which are very good at landing in small locations, but are inefficient, according to Antony Waldock, principal systems analyst at BMT Defence Services.

In a project funded by the Defence Science and Technology Laboratory, the team set about designing a UAV with wing structures inspired by birds.

"The approach we took isn't limited to perching, it could be applied to just about any type of manoeuvre, what we were interested in was being able to control the aircraft in a flexible way, similar to the way birds fly," said Waldock.

The UAV is equipped with wings that are able to sweep forwards and backwards, with hinges in the middle, allowing the aircraft to pitch up and down very quickly. The wing tips can also twist to control roll. The researchers generated a

numerical model of the aircraft using wind-tunnel data, in which they could move the wings forward and back to generate different configurations and monitor the effect, in a similar way to a computer game. They then encoded the particular objective they hoped to achieve.

"Next, we allowed the machinelearning algorithm to determine how best to achieve that objective, from a range of different starting conditions," said Waldock.

The model determined which trajectory to take, in order to achieve the best 'score' in the computer game.

"We trained the algorithm, by letting it play the game over and over again, to learn the model, and then we could query the model, for any given starting condition, to find out the best trajectory or approach to follow to land at the desired location," said Waldock.

When the researchers tested the UAV at altitude, they found it was able to carry out a perched landing at the same location multiple times, with minimal error.



The UAV is equipped with wings that are able to sweep forwards and backwards

MEDICAL

3D bioprinter creates skin

Team develops 3D printer that is able to replicate the natural structure of human skin

Scientists from Spain's Universidad Carlos III de Madrid (UC3M) and Centre for Energy, Environmental and Technological Research (CIEMAT) have developed a 3D printer that produces human skin.

The device replicates the natural structure of skin, with an epidermis to protect against the elements and a

deeper layer of dermis. This thicker dermis layer is made up of fibroblasts that produce collagen, giving mechanical strength and elasticity to the skin. It can be used to treat burns, as well as test cosmetics and pharmaceuticals.

Rather than the synthetic feedstocks typically used in additive manufacturing, patented bioinks are deposited to build up layers of skin. The order in which the components are laid is pivotal, and is controlled by a computer.

"Knowing how to mix the biological components, in what conditions to work with them so that the cells don't deteriorate, and how to correctly deposit the product is critical," said researcher Juan Francisco del Cañizo. **AW**

COMMUNICATIONS

Future antennas are set to go with the flow

Devices to be built from liquid rather than metal

Smaller, cheaper, and reconfigurable antennas could result from a UK research project aiming to build the devices out of liquid, rather than metal.

Antennas are typically built from metals but they tend to be large, heavy and expensive, and cannot be reconfigured to operate across different frequencies. This is likely to become an increasing limitation with the greater wireless communication between even tiny everyday devices in the Internet of Things.

Now, in an EPSRC-funded project, researchers at Liverpool University are hoping to develop small, transparent antennas that could be used in future 5G wireless networks, and in machine-to-machine communication.

Water is known to be capable of acting as an antenna, according to Prof Yi Huang, in the Department of Electrical Engineering and Electronics, who is leading the project.

"Liquids [such as] water are transparent, which makes them attractive from an appearance perspective," said Huang. "The wavelength [of an electromagnetic signal] is also much shorter in liquid than in free space or metal."

Since signal wavelength is directly linked to the size of antenna, this could allow the devices to be built at smaller sizes. "If the wavelength in free space is 1m, in water it would only be around 10cm," he said.

However, the drawback with using water alone as an antenna is that the liquid freezes when the temperature drops below 0°C, he said.

The researchers hope to identify more suitable liquids that can be used as antennas as part of the project, which also involves BAE Systems and Huawei.

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ENERGY

Concentrate hard for solar power

Researchers investigate power plants to reduce cost of technology HELEN KNIGHT REPORTS

heaper and more efficient energy generation from concentrating solar power plants could be made possible, thanks to research

being carried out at City University. In an EPSRC-funded project, researchers are investigating Organic Rankine Cycle (ORC) power plants to reduce the cost of the technology.

Unlike conventional steam power plants, ORCs pressurise and heat an organic fluid to produce vapour, which is then expanded to generate electricity. This allows lower temperature heat sources of 100 to 300°C to be converted into power more economically than using steam.

The technology could be used to produce electricity from low-cost distributed concentrating solar power collectors, or from waste heat generated by large internal combustion engines, according to project leader Prof Abdulnaser Sayma.

However, while ORCs have already been successfully applied on an industrial scale, more research is needed to understand the physics behind the devices when operating at these smaller scales. Devices need to be developed that can operate efficiently over a range of different conditions without altering their fundamental design, to allow them to be manufactured at high volumes and therefore at a lower cost, said Sayma. "There are some gaps in fundamental understanding that we want to explore, to find out how we can select a suitable type that can be used at those different sizes and temperatures," he added.

The researchers plan to investigate two types of ORC power plant for small-scale electricity generation applications of around 50kW.

The devices are based on the use of either turbo or screw expanders. Turbo expanders, which operate at very high speeds, are equipped with

"Screw expanders have the advantage of being cheaper to produce" Prof Abdulnaser Sayma,

City University

a turbine with continuously rotating blades. In a screw expander, in contrast, the vapour is expanded in a cavity to push apart two screws, in a similar way to a piston engine.

"Turbo expanders are higher speed, more compact and have a higher efficiency, but screw expanders have the advantage of being cheaper to produce," said Sayma.

The researchers hope to determine which of the two designs is the most suitable across different conditions. $\ensuremath{\textcircled{}}$

Solar power has the potential to produce electricity from low-cost collectors



SPACE

Suits you, spaceman

The Boeing Blue weighs in at about 40 per cent lighter than previous spacesuits

Boeing has unveiled the spacesuit astronauts will wear on its Starliner low-Earth orbit transport vehicle.

The Boeing Blue is about 40 per cent lighter than previous spacesuits, weighing in at 12lbs. Instead of rigid body supports and neck rings, it features zips in the torso and neck area for greater flexibility and comfort. Mobility joints in the elbow and shoulder allow movement even when the suit is pressurised. A soft hooded helmet has an integrated headset, as well as a wide polycarbonate visor to enhance peripheral vision.

According to Boeing, permeable

MEASUREMENT

Optical fibres shed light on tissue content Researchers develop new

technique for production

Portable scanners that detect cancer and endoscopes that analyse the content of tissue could be made possible using optical fibres that emit long-wavelength mid-infrared light.

Now, in an EPSRC-funded project, researchers at Nottingham University are developing a new technique to produce these fibres.

Mid-infrared light waves oscillate at frequencies that match the typical range of vibrations of molecular bonds, making them suitable for analysing the molecular make-up of numerous samples.

However, existing mid-infrared spectrometers emit a very weak light signal. Laser-pumped optical fibres, in contrast, have the potential to emit much brighter mid-infrared light. In a paper published in *Nature Photonics* in 2014, a team led by Prof Angela Seddon at Nottingham University produced a long wavelength optical fibre that emitted a record broad range of frequencies of mid-infrared light.

This mid-infrared supercontinuum can be shone at a sample, where it interacts with the molecular bonds



The suit is for near-Earth missions

layers allow water vapour – but not air – to pass through the fabric. In a nod to the digital age, the suit's gloves are equipped with material for interaction with touchscreens.

Intended for near-Earth missions, the suit is designed to protect astronauts in the event of cabin fires or depressurisation. It was developed with the help of former NASA astronaut Chris Ferguson. **AW**



Mid-infrared light waves

within it. The light that hits the detector after this interaction can then be analysed.

However, the existing method of producing these optical fibres is problematic; different glasses are first purified, and then melted together, before finally being shaped, in a process that takes eight weeks. The glass-melting process alone can take 32 hours.

So the team of researchers is now investigating the use of microwave-assisted heating to speed up this process.

The metalloids used to produce the glass contain free electrons that interact with the microwave field, causing the temperature of the material to rise. But because the containers in which the glass is melted do not interact with the microwaves the process allows higher temperatures to be reached, said Seddon.

This significantly speeds up the melting process, reducing it to 30 minutes, she added.

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ELECTRONICS

Sensors are now well-worn items

Technology could allow wearers to become mobile sensors in urban areas Helen KNIGHT REPORTS



mart clothing that interacts with its wearer's urban environment is being developed by researchers in the UK.

The technology could allow the wearers themselves to become mobile sensors, improving pollution and traffic monitoring within cities, and helping to coordinate evacuations during major incidents or disasters.

The wearable sensors and electronics could also allow wearers to receive personalised entertainment, healthcare and shopping services as they travel through a city or building.

The project, which is being led by Prof Steve Beeby in the Department of Electronics and Computer Science at Southampton University, will develop the low-energy sensors and artificial intelligence needed to allow people's clothing to communicate with smart city network systems.

"Most of the sensors that are used in smart cities are fixed, on lampposts for example, and there has been some work to put them on vehicles such as buses, but we are looking to put them on people, in something they can just put on and wear," said Beeby.

The technology will offer a better distribution of sensors throughout a smart city, and could allow researchers to influence the density of information they receive, by offering incentives for wearers to visit particular areas, for example. "It provides a flexible, moveable input to the smart city, which isn't possible with the existing fixed sensor network," said Beeby.

The research builds on another EPSRC-funded project the team is involved in, which is developing the technology to place electronics, including microprocessors, microcontrollers and logic circuits, into textile yarns. These yarns can then be woven into wearable fabrics.

The researchers are now planning to incorporate MEMs-style sensors alongside the electronics in these yarns, to allow them to detect pollution levels, for example.

The team will also investigate energy-harvesting technologies to power the sensors and electronics. These include piezoelectric films and ferroelectret materials, or thin-film polymer foams that generate electricity when compressed. "So, for example, if you were to put these in an insole, they would not only be very comfortable, but they would also generate a pretty significant amount of energy," said Beeby.

The researchers are working on the project with ARM, Mayflower Complete Lighting Control, NquiringMinds, and Smart Garment People.



MATERIALS

Now's the time for slime

Biomaterial mimics the behaviour of fish slime used to obstruct the gills of predators

An artificial biomaterial that is based on the slime that is secreted by the Pacific Hagfish could have applications in marine defence.

Developed at the US Navy's Naval Surface Warfare Center, the material mimics the behaviour of the slime that the fish secretes to obstruct the gills of predators.

The group, led by Dr Josh Kogot and Dr Ryan Kincer,

believes that the material could be used by the navy for ballistics protection, anti-fouling, or as an anti-shark spray for divers.

Kincer said hagfish slime owes its properties to two protein-based components: a thread and a mucin.

"The coiled-up thread behaves like a spring and quickly unravels upon contact with water due to stored energy," he explained. "The mucin binds to water and constrains the flow between the micro channels created by the thread dispersion. The interaction between the thread, mucin, and seawater creates a three-dimensional, viscoelastic network. Over time, the thread begins to collapse, causing the slime to slowly dissipate." **JE**

MATERIALS

Life is shell for biodegradable shopping bags

Project offers alternative to oil-based plastics

HELEN KNIGHT REPORTS



Biodegradable shopping bags made out of discarded shrimp shells are being developed by researchers in the UK.

The project, which is being led by Dr Nicola Everitt at Nottingham University alongside researchers at Nile University in Egypt, is aimed at developing an alternative to oil-based plastics for use in packaging.

By developing the biopolymer bags, the researchers hope to help reduce the significant waste problem in Egypt, as well as producing a new food packaging material to extend the shelf life of products in countries such as the UK.

"Only around 50 to 60 per cent of Egypt's waste is actually collected, and the rest lies around in plastic bags at the end of the street and by the roadside," said Everitt.

To develop the bags, the team of researchers is investigating the use of chitosan, a man-made polymer derived from the organic compound chitin, which is extracted from the shrimp shells. Shrimp shells are themselves part of Egypt's waste problem.

Chitosan is a promising biodegradable polymer, which is already used in the arena of pharmaceutical packaging due to its antimicrobial, antibacterial and biocompatible properties.

From each kilogram of dried shrimp shells, the researchers hope to make 10-15 biopolymer bags.

The shells are first washed and then boiled in acid to remove the calcium carbonate 'backbone' of the crustacean. They are then washed again before being bathed in an alkali, to remove protein from the material, leaving the long molecular chains that make up the biopolymer.®





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MEDICAL

Getting right to the heart of the matter

Machine learning is used to assess people's heart conditions HELEN KNIGHT REPORTS

> rtificial intelligence could one day help doctors to predict which of their patients are at greatest risk of dying of a heart

condition, allowing them to be treated more effectively

Researchers at the MRC London Institute of Medical Sciences (LMS) have for the first time used machine learning to interpret heart scans, to predict how long patients will live.

The research, published in the journal Radiology, found that the Al software could predict survival at one year with up to 80 per cent accuracy, according to Declan O'Regan, who led the project.

"We studied patients with pulmonary hypertension, which is a devastating disease that causes heart failure, where pressure builds up in the blood vessels of the lungs and then feeds back into the heart," said O'Regan. "It can cause about one third of people to die within five years of diagnosis," he added.

The key to treating the disease is to identify which patients are at greatest risk of developing heart failure, so that they can be targeted with the

most intensive treatment, said O'Regan. However, predictions made today are often inaccurate.

The machine-learning software automatically analyses moving images of a patient's heart captured during an MRI scan. It then uses advanced image processing to build a virtual 3D heart, which replicates the way over 30,000 points in the heart contract during each beat.

The researchers fed the system historic data from over 256 patients with pulmonary hypertension. By linking these data with its models, it learned which attributes of a heart, its shape and structure, put an individual at a given risk of heart failure.

"It can find the really earliest signs of heart failure that are difficult for humans to spot," said O'Regan.

The researchers now plan to test the software on data from a different hospital to that from Hammersmith Hospital, where it was developed, in order to verify its accuracy.

They also plan to use more advanced AI, according to O'Regan.

"We want to use techniques such as deep learning, to try to improve on the techniques that we have, and to build a more detailed picture of the whole heart," he said.

The software analyses moving pictures of a patient's heart Image: MRC LMS.



ELECTRONICS

Aerial abilities

'Backpack' allows developers to tap into and control the flight of real-life dragonflies

Engineers in the US have developed an electronic 'backpack' that can be used to hack into the nervous system of a dragonfly and control its flight.

A number of groups around the world - primarily in the military sphere - are working on the development of tiny flying vehicles that replicate insect flight. Dragonflies are of particular interest because of their energy efficiency and aerobatic abilities.

The DragonflEye project brainchild of Draper, a Massachusetts non-profit R&D organisation - offers an intriguing alternative to the challenge of building mechanical flying insects by tapping into the aerial abilities of real-life dragonflies.

ROBOTICS

Robot fingertip has the really common touch

Device is a webcam inside a 3D-printed soft fingertip HELEN KNIGHT REPORTS

A low-cost robotic fingertip with an artificial sense of touch mimicking that of humans has won an international soft robotics competition

TacTip is a 3D-printed sensor developed by the Tactile Robotics Team at Bristol Robotics Laboratory (BRL). The device consists of a webcam mounted inside a 3D-printed soft fingertip.

The webcam tracks the movement of pins inside the device, which act like



TacTip is a 3D-printed sensor



The electronic 'backpack' in situ

The system works by sending guidance commands from the backpack to special 'steering' neurons inside the dragonfly nerve cord.

These commands are effectively pulses of light, which are piped to the insect's neurons along specially developed optical structures called optrodes. While conventional optical fibres are too stiff to be wrapped around the dragonfly nerve cord, optrodes are flexible and able to bend light around sub-millimetre turns. JE

the touch receptors in human fingertips, according to Dr Nathan Lepora, senior lecturer in robotics at Bristol University and BRL, and leader of the Tactile Robotics Team.

"The tip is designed with an outer surface made of rubber, so it bends, and on the inside are a number of pins with white tips," said Lepora. "As the material deforms, the pins move, and the camera picks up this movement, to act as a tactile sensor.'

The movement of the pins can be used to provide information on the shape and position of an object, as well as its contact force, torque and shear. The sensors, which can be mounted on robotic arms or hands, could give future robots human-like dexterity. Robotic fingers with an artificial sense of touch could be used in manufacturing, food production and healthcare, and prosthetic hands.

The device was awarded first prize in the Contributions in Soft Robotics Research category at the 2016 Soft Robotics Competition. "Tactile robotics is



The device has an open-source design, allowing researchers to build a fingertip with a 3D printer.

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Engineers in the picture of health

Engineers should be given more of an opportunity to help address the challenges facing the UK's beleaguered health service



he financial struggles of the National Health Service (NHS) have been dominating the headlines for many months now; inefficient services and overwhelmed hospitals are cited as the root causes. Yet with people living longer lives, a continually growing

population and more advanced and increasingly expensive treatments becoming available, the £115bn cost of the NHS can only continue to rise.

I am often asked why engineers are concerned about the NHS. Aside from all of us being patients at some point in our lives, the reason we are concerned is the largely hidden and undervalued contribution engineers make to our NHS every day. I am not simply referring to the 3,000 UK SMEs, designing and manufacturing cutting-edge healthcare devices and equipment, but the thousands of engineers within the NHS itself, working in areas such as prosthetics and orthopaedics, renal care, rehabilitation, imaging and modelling, as well as tele-health and robotics.

While the debate on 'pressures on front-line

services' rages on, the one area that has so far been overlooked is the role of technology. Technology and the biomedical engineers who develop, procure and maintain this technology. have the potential to not only ease the burden on services but also significantly cut costs.

The Institution of Mechanical Engineers recently carried out a member survey and, of the 200 engineers who responded, 94 per cent said that the UK should have a chief engineer, similar to a chief nurse or chief medical officer, to oversee the use of medical equipment in every NHS Acute Trust. The majority (86 per cent) think that giving engineers more responsibility for the procurement, maintenance and calibration of medical equipment would help the NHS meet the government's efficiency savings, while 80 per cent said it would ensure NHS patients have a better experience when under hospital care. Perhaps surprisingly, nearly two-thirds of those surveyed (65 per cent) also said that engineers working in the NHS should have more hands-on involvement with front-line patient care.

The engineering community is clearly confident that they can make a difference and giving engineers already working in hospitals more responsibility for medical equipment would be a step-change in our approach to medical care in the UK.

Technical innovations are set to revolutionise healthcare in the coming decades. Big data will allow doctors to undertake predictive modelling and trending to pinpoint, for example, outbreaks of disease linked to environmental conditions. The development of tele-health and smart

Innovations in tele-health can help ease the burden on clinical staff

phone apps that access body-worn measurement systems are also set to transform the way illnesses such as diabetes and heart disease are controlled and monitored. Surgical robotic manipulators will become more prevalent, allowing surgeons to navigate deep inside the body, avoiding the risks and complications of traditional open surgery. Such innovations will allow even complex interventions to be treated as day cases. All of these technologies not only look set to improve patient care, but also help ease the burden on increasingly overworked clinical staff. In order to properly exploit these technologies, however, we need engineers.

Biomedical engineers are already working in the NHS, providing a crucial role in the development. selection, use, maintenance and decommissioning of technologies. However, unlike many other NHS professions, there is little uniform recognition of the biomedical engineer. NHS biomedical engineers are often assigned to different departments, operate at different levels of authority and have varying input into critical decision-making, depending on which trust they are employed at. This inconsistency not only undermines the work of engineers, but hampers connectivity between trusts on the development, procurement, maintenance, and sharing of medical equipment. This lack of cooperation and coordination between expert NHS engineers is preventing huge cost savings and efficiencies related to medical equipment, which could be made without affecting front-line services. It is estimated that including engineering into this process has the potential to save the NHS over £700m each year.

The Institution of Mechanical Engineers is leading a campaign to create a chief biomedical engineer position in each NHS Acute Trust, working alongside roles such as the chief nurse and chief pharmacist; with consistent qualifications, level of authority, decision-making abilities and connectivity with other trusts. This would not only increase the opportunity for cost savings but also encourage best practice in the procurement, maintenance and use of medical equipment as well as inspire technological innovation.

In many trusts, this position and role will already exist, albeit under different titles, departments and levels of authority. The costs of implementation would be negligible, but the benefits to patients, services, budgets and the NHS would be significant.

Dr Helen Meese, head of healthcare at the Institution of Mechanical Engineers



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Thehottopic

After Bernie Ecclestone The end of the Formula One chief's reign prompts a lively debate on the future of motorsport

What must be stopped is the last 20-plus years' line of 'progress', which has continually extended the benefits of having more resources in the bigger teams. By stifling innovations, the smaller advantages are far harder to gain, paralysing development and allowing the big boys to stay ahead. My fervent hope is to see something as radical as the Brabham Fan Car, but for now I'll settle for overcoming the tedious procession behind the fastest qualifier. And abandoning the stupidity of DRS, which eliminates overtaking in place of passing when it's your turn. **Mike West**



Aside from having all the current safety precautions and, say, a weight and width limit, Formula One should be a no-holds-barred battle of automotive technology, which should result in rapid innovation and development. Frankly anything is going to be better now that Bernie Ecclestone is removed from the equation.

Peter Thomas

I think there should be a lot less regulation on engine and chassis development, but also more focus on what a driver can bring to a team. (I agree with the radio ban in principle, drivers are helped too much). Accept the fact that Formula One is an expensive and largely wasteful sport so bring back in-season testing, eliminate a cap on engine rpm, and let the engines have as many cylinders as the designers see fit. A grid with V8s, V10s and V12s was the best grid ever. Up the engine capacity back to 3 litres, or have a N/A option at 3.0 litres. Keep pit stops and bring back refuelling. Fundamentally, bring back the race, stop preserving fuel and tyres; we want to see cars go 100 per cent flat out for 100 per cent of the laps - go hard or go home! Andrew

I have believed for a long time that aero should be banned altogether. The cars should only run neutral downforce: it would first eliminate a huge expense that smaller teams can't hope to compete with. Second, it would slow corner speeds dramatically, thereby increasing safety; when a car glued to the ground by aero leaves the track it is likely to accelerate momentarily when the energy from 'downforce' is liberated. Cars could follow each other through corners, without aero disturbance, and properly slipstream into the next braking area, which would also be longer, carbon brakes or not. Suspension would become a bigger part of the handling conundrum once again, rather than relying on fractions of psi in tyres. Tyres wouldn't be subjected to silly downforce and while mechanical grip would be vital, tyre life and condition would be less critical. Straightline acceleration and speed would also be greater for a given engine size without the enormous drag of aero.

David Redfern

Get rid of carbon brakes – this would lengthen the braking distance, which is where the very few overtakes take place. Go back to proper tracks that test the car and driver, not these dull computer-generated things we have nowadays. **David Murphy**

I think a budget cap on total spend that can be achieved by all Formula One teams would be appropriate, so that Ferrari and so on do not just overspend to win. It would mean that each team could have the possibility of achieving the same level of ingenuity or efficiency. This also needs easy-to-understand rules and that do not inhibit technological enhancement, such as maximum dimensions, no fuel stop and so on. This would lead to active aero that may mean better racing as cars could travel closer, and advancement of technology. John Hargreaves

Inyouropinion

On the precipice?

Brexit continues to divide opinion among our readers

Great Britain, not the UK, is stumbling to the cliff-edge and a 'calamitous act of self-harm'. This at a time when we must work together in Europe to try to mitigate the far more serious issues of catastrophic climate change and an unsustainable global population. **William Dick**

It will be interesting to see how Brexit plays out. Meanwhile a lot of people are running scared. Including some of my customers. **Michael Reid** As a relatively late Brexit convert, I believe that the threats are over-hyped while the benefits are harder to quantify at this time. The more data about our EU involvement that I see, the more I believe that we gained little from the years of EU membership. We have been a cash-cow to the EU while cutting off a lot of world trade where the UK has still got a great reputation for quality and honesty. Jack Broughton

My major concern with Brexit is the impact on long-term major capital investment. For certain industries (for example, mass-market cars, bulk chemicals) the UK market is too small to justify major investment in my experience, and the high global logistics costs mean they are dependent on local regional markets. These industries are important UK exporters and without EU-free trade are likely to wither away over a number of years without EU free-trade agreements. **David Beavis**

Teaching the tech

The suggestion that the delivery of technical education is rethought sparked a familiar debate

The answer is very simple. Stop treating every degree subject as equal. Subsidise courses and offer grants in the subjects this country needs. Universities are run like businesses these days. Restructure the system so that offering STEM subjects is more profitable. **John Yeatman**

The focus on degrees is a problem. Not everyone needs such a qualification and in the engineering industry there is perhaps more need for practitioners and technicians rather than design engineers. There are far too many people with degrees when most jobs don't warrant that level of education and many of them have been given an expectation of a grand job, when the reality is more



Thesecretengineer

Our anonymous blogger ponders the benefits of an engineer's approach to information



We are living in strange times where, out in the wider world, misinformation focusing on details taken out of context regularly shares space with lies and outright deceit.

By contrast it is the role of the engineer to take a holistic approach and to be scrupulous in the application of information, particularly with regard to its accuracy and validity. In fact, I suspect that if engineers ran the world it would be a little more dull but altogether better.

The current shenanigans in the halls of power, ably aided and abetted by the media, serves as a reminder of just how careful we have to be.

Even without any Machiavellian intent, it is all too easy to fool ourselves into interpreting information to support our own views. I am sure we have all been in the situation where testing a new product has resulted in ambiguous results. In particular, I remember my work on an Advanced Airflow Widget, required to improve performance under load. Due to cost and time limitations we were restricted as to what we could do. I tried a demon tweak inspired by the inimitable Mr Bernoulli and it seemed to work, so I ran a number of tests that gave a repeatable improvement/deterioration. I gathered the great and the good for a demonstration but for some reason the results on this occasion proved to be less clear cut. As my superiors were getting a tad rattled by the fast-disappearing timeline this avenue of investigation was brought to a halt.

I would say they chose a path that ignored previous evidence because they were selectively basing their decision on the one demonstration. I suspect they would say that I was wilfully seeing a pattern in what, with additional testing, would prove to be a temporary bias to an essentially random process. Of course, it could be argued the problem was actually not building enough time into the project to develop the technology required to meet the challenging goals.

I was reminded of all this recently by a journalistic piece about a new electric car. Much was made of this latest whispering-chariot's range, speed and recharge time. Still lauded as an environmental saviour, this particular example demonstrated a specification that truly does make it a viable alternative to petrol cars.

What about the battery? What of the sourcing of the raw materials, its predicted service life and disposal? Until these problems are seriously tackled it is not a solution to our eco-worries, it is just a different problem. Even in areas that we engineers take a lead, it would appear that we still need to beware of spin and obfuscation.

mundane. Companies should take more interest in training people for what they do, rather than continually poaching those who do get trained. **Nick Cole**

It has to be recognised that universities can only deliver analytical skills; unfortunately, industry needs engineers who can design and manufacture processes, tools, machinery and control systems. While universities focus on creating analytical skills, there is no follow-on institutional structure for transforming this know-how into skills in the design (and manufacture) of processes, tools, machinery and control systems; post-university training to develop such skills has yet to be defined. **Raj Balendra**

Most people going into industry now want the high pay and unaccountable managerial roles where they have little or no responsibility. Unfortunately these 'skills' are invading our educational system and until we can get that back to basics working from the ground up you've no chance. I predict lots of meetings and plenty of colourful spreadsheets in the future highlighting what I mean. **Dan Yates**

Once again, a report working on the assumption that the education system is there to produce people qualified for jobs, which, it predicts, will come into existence. That is not what education is about. It is there to develop the individual according to his/her abilities and desires, and not to persuade people to do courses because we need people in that area. Schools and universities are to satisfy the demands of pupils. **Allen Williams**

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WE CREATE MOTION

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Sharpening up the UK's cutting edge

The UK's undoubted ability in the arenas of innovation and start-ups needs harnessing to create a set of world-beating businesses



etting out the case for business support in its recent green paper Building Our Industrial Strategy, the government hailed the UK as a "success story for start-ups". Some 350,000 new enterprises were registered in the UK in 2014, it explained, going on to acknowledge that we need to marry start-up culture with the right support and investment to raise productivity.

Some of the UK's most innovative new companies have been built around technology developed in our universities, and it is encouraging to see government

directing attention towards supporting these businesses through their initial stages. By exploring the impact of different university commercialisation approaches, including the varying size of equity stakes taken, we hope that the government can facilitate the sharing of valuable 'best practice'.

The UK scores highly in innovation league tables - it came third in the 2016 Global Innovation Index - and one of the factors underpinning this success is

undoubtedly the strength of its universities. In recent years, substantial progress has been made in university technology-transfer activities and some UK universities, Cambridge being perhaps the most notable example, are looked to as exemplars of global best practice. But technology transfer continues to be a topic of interest and debate, as illustrated by the current House of Commons Science and Technology Committee inquiry.

The Royal Academy of Engineering's experience of supporting academic entrepreneurs suggests considerable variation in the approaches adopted by UK universities, not all of which can be explained by the different levels of

support they have provided. We have also found that academic entrepreneurs can be disadvantaged in negotiations on IP and equity due to their lack of prior experience and knowledge of the spinning-out process. Bridging this information gap would help to make the process fairer and more transparent. We also believe that the maturing of technology-transfer support in the UK provides an opportunity to create a more vibrant market in this arena. As is already the case in some universities, academic entrepreneurs who feel that they can access the support they need beyond their university's technologytransfer office should be able to do so, and the equity stake then taken by the university should reflect this.

While appropriate funding is essential to get a business

determine its longer-term viability. The advice of a seasoned entrepreneur in navigating business growth can be invaluable, as can access to strong networks. The Royal Academy set up its Enterprise Hub to help provide this missing link. Now in its fourth year, the Hub offers financial support to entrepreneurial engineers, as well as intensive business training and invitations to exclusive networking events with corporates and investors. It also - uniquely - draws on the support of the nation's leading engineers, who serve as mentors for Hub entrepreneurs. These

off the ground, other factors may



Many innovative companies (such as Ultrahaptics - see p22) began life in our universities

experienced business leaders, most of whom are Academy Fellows, offer expert advice at the time it is most needed. Their support is provided pro bono and neither the academy nor the mentors take any equity.

As the government's green paper says, support and investment are both vital, and this wider package of mentoring, training and networking can be the key to making an entrepreneur investment-ready. Since 2013 the Hub has supported over 40 start-up companies which, between

them, have created over 150 jobs and raised over £30m in follow-on funding. It also provides support to help established SMEs navigate the scale-up process.

The Royal Academy has been busy over the last year developing a physical home for the Enterprise Hub. The Taylor Centre opens this month and will provide facilities for enterprising engineers and their stakeholders to work on commercialising their innovations and building successful businesses. It is appropriately named after the entrepreneur Dr John Taylor OBE FREng, who invented the thermostatic control used in cordless kettles.

The engineers responsible for a series of innovations with similarly global impact have just been announced as the winners of the 2017 Queen Elizabeth Prize for Engineering. Four engineers who pioneered three generations of innovation in digital image sensors share this year's £1m prize. Michael Tompsett from the UK, Nobukazu Teranishi from Japan, and Eric Fossum and George Smith from the US made seminal contributions to capturing and distributing images.

The engineering profession will be coming together under the Engineering the Future initiative a grouping of the 38 organisations representing UK professional engineering - to prepare a professionwide response to the government's green paper on industrial strategy. How we can harness the UK's engineering strengths to ensure that, as well as creating innovative technologies, spin-outs and start-ups, we grow more worldbeating businesses and industries of the future, will be at the heart of that response.

Dr Hayaatun Sillem is deputy chief executive of the Royal **Academy of Engineering**



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DISPLAYS

Changing perceptions

Advanced control and display technologies that monitor our moods and augment our view of the road are poised to reshape our relationship with the car. Jon Excell reports



While once they were little more than elegant chunks of mechanical engineering designed to get us from A to B, our cars are rapidly evolving into sensor-rich consumer devices: bristling with intelligence and connected to the world around them.

But as they become smarter and more sophisticated, what does this mean for the drivers and passengers?

How will we communicate with our vehicles and make sense of the vast amounts of information they gather? And how will their intelligence be used to improve and enhance our experience rather than plunge us into a thick data-fog of distractions?

Addressing these challenges is one of the car industry's most pressing and exciting areas of research. And a host of advanced control and display technologies – from gesture control systems that create the illusion of touch in mid-air to mind-reading steering wheels able to monitor a driver's alertness – promise to fundamentally reshape our relationship with the car.

A key area of development is in the field of head-up displays, or HUDs: transparent screens that place information directly in a driver's line of sight and reduce the need to look away from the road.

HUDs have been available on some production vehicles for a number of years, primarily in the form of so-called combiner devices that pop out of the dashboard and overlay the driver's view with basic information such as speed and navigation cues.

But the next generation of the technology promises a new level of sophistication, with much larger augmented reality (AR) displays enhancing the driver's view of the road with a rich array of navigation prompts, safety cues and even the kind of infrared night-vision capabilities more commonly associated with the military.

In a striking illustration of the way in which the worlds of automotive and consumer electronics are moving closer together, advanced HUDs were much in evidence at this year's CES show in Las Vegas, where a range of car-makers and automotive suppliers demonstrated different visions for the future. Among them, electronics giant Panasonic unveiled an AR system that dispenses with the combiner screen and instead projects images directly onto the inside of the windscreen.

Demonstrated on board a modified Renault Twizy, the system is claimed to be one of the largest and most sophisticated automotive HUDs yet developed. Processing information gathered by eight cameras mounted on the outside of the car, the technology augments the driver's view with information from up to **01** HUDs that project directly onto the windshield are a key area of development *Image: JCR* 10m in front of the car, and – with a field-of-view of 12° to the horizontal and 5° to the vertical – is claimed to cover a larger portion of the driver's observable world than any other automotive HUD. Cameras inside the car track the position of the driver's head and eyes to ensure that this augmented view is always placed precisely within line of sight.

It is an innovation that Fabien Roth, general manager at Panasonic Automotive & Industrial Europe, believes could open up a range of new application areas for HUDs.

He said: "You have traditional information such as speed, different warnings and navigation, but you can also use it for safety – for instance with lane departure systems – and you can even provide contextual information. For example, you could indicate with an arrow where a restaurant or petrol station is and, because the car is connected, you could provide info saying: 'There's one table free at 8 o'clock. Do you want me to book it?'"

Although Panasonic's system is very much a proof-of concept, there is clearly a high level of interest across the industry in this kind of technology. Lee Skrypchuk, a human machine interface (HMI) technical specialist with Jaguar Land Rover (JLR), told *The Engineer* that HUD is a major part of





the UK firm's strategic roadmap. "We've talked about enhancing the view of the driver and view of the occupant to give them more vision of road or to augment information from the real world," he said.

A key JLR initiative in this space is its so-called virtual windscreen project, which, along with displaying AR information on the windscreen, is also exploring the use of screens in the car's roof pillars to eliminate blind spots and give the driver a 360° view around the vehicle. The firm has also been exploring a concept dubbed Transparent Bonnet, which uses cameras in the grill to stream data to a HUD and create a see-through view of the terrain through the bonnet.

In the longer term, Skrypchuk anticipates the development of windscreen-wide HUDs that augment a driver's entire view. However, there are significant challenges to achieving this, he said, not least the wide variety of shapes and sizes of windscreen.

"The windscreen is a complex beast and starting off with an image at reasonable size and resolution and manipulating it up to windscreen size is quite difficult."

But HUDs are not the only type of

02 Bosch's concept for an ultrasonic haptic display

advanced display system under development. For example, BMW used CES to demonstrate a holographic display that floated in mid-air directly next to the steering wheel. This HoloActive Touch system is designed to complement BMW's existing gesture control technology by enabling users to interact with the display through hand gestures.

Even more intriguingly, a number of firms are looking at pairing gesture control systems with a form of haptic or tactile feedback that enables users to actually feel virtual switches and buttons.

In a striking example of this, engineers at Bosch recently demonstrated a concept car equipped with an ultrasonic haptic system that guided the driver's hand to the right place to perform a gesture command. Based on technology developed by University of Bristol spinout firm Ultrahaptics Ltd, the system uses ultrasound to project sensations >>

"You could indicate with an arrow where a restaurant is and provide info saying: 'There's a table free at 8 o'clock. Shall I book it?'"

Fabien Roth

03 JCR's Mindsense concept uses steering-wheel sensors to monitor brain waves

> 04 Panasonic's AR windshield HUD boasts one of the widest fields of view yet

>> through the air. For the Bosch application, it was used to create the sensation of a forcefield around the gesture interaction area, but the technology can be employed to produce a range of more complex tactile sensations.

Explaining how the underpinning technology works, Ultrahaptics CTO Tom Carter said: "The hardware itself is made up of a small collection of ultrasound speakers. We trigger each of the speakers with very slight time differences between them so that the sound waves travel through the air and all arrive at the same point at the same time. At the point at which they all overlap, you get one very localised point of high pressure and at that point there's just enough force to slightly displace the surface of the skin."

By controlling that effect, he explained, the system is able to create different frequency vibrations on the skin that can replicate a range of sensations. And the Bosch application is just a taster of what carmakers may use the technology for in the future.

"If you combined our technology with a gesture control system, you could press buttons or operate controls in the air and get immediate tactile feedback as if they were actually there," added Carter.

In the meantime, Jürgen Cordes, Bosch project manager for multimedia, is excited about the technology's potential to reduce distractions and help keep the driver's eyes on the road. He told *The Engineer* the firm was hoping to work with OEM partners on taking the technology closer to production.

While the current vision is to use these kinds of control system to operate non-critical features, JLR's Skrypchuk believes that, in the longer term, they could play a more direct role in controlling the vehicle.

"Once we move into autonomy, we'll start to see some really unique methods of controlling the car," he said, "not necessarily where you're steering or braking but maybe indicating to the vehicle that you want it to carry out a manoeuvre, or pointing towards a certain direction that you want the car to go in."





"A large amount of the testing will look at the effects on driving activity of the technologies that we're putting in the car"

Lee Skrypchuk

But while they're compelling propositions don't these technologies risk overwhelming and confusing the driver? A key part of the technology development process is

ensuring that this doesn't happen. For example, at JLR the engineering team works closely with human factors specialists and psychologists to ensure that the interfaces are truly user friendly.

"We spend a reasonable amount of time creating simulators of the technologies so we can test them with a range of participants to see how different age groups, different cognitive abilities, different ethnic backgrounds can affect the performance of the system," said Skrypchuk.

"A large amount of the testing will look at the effects on driving activity of the technologies that we're putting in the car. When information goes into the user's mind, what does that invoke as a response? Does it cause issues such as cognitive tunnelling or high levels of workload?"

Another factor in ensuring these technologies work in perfect harmony with the driver is coupling them with systems that monitor a driver's behaviour and state of mind. VW, for instance, recently announced that it was working with computing giant NVIDIA on the development of an artificially intelligent 'cockpit' that monitors a driver's behaviour and uses AI to anticipate his or her needs. Toyota recently demonstrated similar concepts on board its Concept-i vehicle.

Meanwhile, JLR is looking at a range of systems for monitoring everything from eye movement and heart rate to skin resistivity and even through a project known as Mind Sense, a driver's brainwaves.

As previously reported in *The Engineer*, this latter initiative is exploring the use of steering-wheel sensors to monitor brain activity and gauge a driver's level of alertness.

The technology works by monitoring the presence of theta waves – a distinct form of brainwave that is prevalent during daydreaming. JLR believes that, by detecting a spike in these signals, the system will be able to detect when a driver's concentration is waning and will trigger some form of alert to raise the driver's awareness.

As well as easing the live interaction of the driver with all of this technology, these kinds of system can also feed into the design activity.

"Not only can it help in understanding whether they're cognisant enough to take control of an autonomous car," said Skrypchuk, "but it can tell us how they're finding the interface experience, and we can use that information to feed into our design process. For instance, if we find a particular interface is demanding for the user, we can investigate ways of making it less demanding"

It's all fascinating stuff. However, given that the long-term vision for the automotive sector is the fully autonomous car, will the passenger of the future in fact need any help? Could this golden era of HMI innovation actually end up being relatively short-lived?

Skrypchuk doesn't think so. "The day where you're able to get in a car, push a button and travel from A to B is some way off," he said, "but even in those situations the technologies are still relevant. How they're used will change and you won't have to worry so much about distractions and the demand they're placing upon the user."

He added that the technologies may also become a key feature when car passengers of the future feel like having a good old-fashioned drive.

"Some people may still want to drive," he said, "and in those situations, where people are perhaps less practised at driving, these technologies can be there to support them when they want to take control of the vehicle." $\ensuremath{\textcircled{}}$

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Taking pains to innovate

A Guildford-based company continues to break new ground in the pursuit of medical technology. Stuart Nathan reports

> t's often said that, despite the large budgets and dedicated facilities available to corporations, the most innovative companies are the smaller ones. Morgan Innovation and Technology (IAT) is a case in point. Based in an identikit building on an identikit industrial estate near Guildford, the company operates mainly in the highly regulated and competitive medical technology sector, and specialises in new technologies.

The Engineer met Nigel Clark, Morgan IAT chief executive, who has taken over the running of the company from his father, Howard, who founded

Morgan with his wife Sue around 30 years ago. The company offices above the shop floor have the cosy atmosphere of a small family operation, even including a large friendly dog whose toys litter Sue Clark's office, where she still oversees company finances.

Howard Clark worked for British Steel as an electrical engineer for many years, and founded Morgan to commercialise a device to alleviate chronic pain. Based around radio-frequency nerve ablation, which involves directing microwaves at the nerve transmitting pain to the brain to heat water in the nerve sheath to prevent

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the pain signal from travelling, Clark developed a range of devices under the name Neurotherm. "My father invented it with my brother's godfather, who was a GP living down the road; this was an entirely new process and it is still the leading device for this form of pain relief," Nigel Clark explained. "We sold the rights about 25 years ago to a very large medical equipment company based in Minnesota; we manufacture the device for it and it sells it around the world. We make about 600 per year. The device itself is worth a few thousand pounds, but it's one of these things where the money is made on the consumables: every use of the machine requires a fresh needle. Each treatment lasts between one and five years, and it's extremely effective; there are some cases where patients have come in using a wheelchair and walked out."





Personal connections such as this seem to have been very much a running theme in Morgan's development. Both Howard and Nigel often start stories with phrases such as "I was sitting next to a chap at a dinner party" or "we met some people at a trade exhibition". It explains what might seem a lack of coherence in the company's products: unlike companies that develop around a specific technology or a range of related conditions, Morgan's portfolio is extremely diverse with the only common thread seeming to be addressing conditions that lack effective treatments.

Take snoring, for example. It's annoying and can be harmful when it interferes with sleep patterns, but except in cases where it is a symptom of severe sleep apnoea, where the sufferer actually stops breathing while sleeping, it is notoriously difficult to treat. Morgan is currently developing a device developed by a consultant at King's College London for mild apnoea that attaches to the underside of the jaw and uses a mild electric current to stimulate the muscles of the tongue just enough to tense it and prevent the vibrations that cause snoring, but not enough to wake the user. "You attach the device to an adhesive, conductive pad that sticks just behind your chin and adjust the level of stimulation yourself; it works little bit like a TENS machine for controlling pain," Clark said. "We carried out a clinical trial with the team at King's that was published earlier this year [2016], and it could be on the market in the next couple of years."

"We are a family company and we make good money. Our overriding drive is to produce products that will generally make a difference"

Nigel Clark, Morgan IAT

01 Employees at Morgan get to work on assembling Neurotherm devices

02 The inflatable incubator could help to save the lives of premature babies born in developing countries or refugee camps One of Morgan's strengths as a small company is its ability to do development work in house and work closely with its medical collaborators. Another of its products, a device to prevent and treat diabetic foot ulcers, is a case in point. "The original company developing it had been working on the concept for a couple of years and had been to various consultants to turn it into a product but without any luck," Clark explained. "We can consolidate all the development areas and we negotiated a deal whereby we gave it 12 months of credit because it was a start-up, and we became the manufacturer at the end of it."

The device fits inside a large shoe, and consists of a series of bladders set into the insole that inflate and deflate to relieve pressure on the sole of the foot, controlled by an electrical unit containing pumps that sits at around calf level. The company is now launching an aggressive sales strategy in the US, with a softer launch in Europe and Australia.

Developing the diabetic boot led to another chance connection. Howard Clark, who has stepped back from running the company but is still heavily involved in development and engineering, was in fact looking for somebody to supply a waterproof sleeve to protect a cast on his wife's leg after she was injured in a car accident, and found a prospective supplier via a leaflet in a doctor's waiting room, Nigel related. "It turned out to be only 20 minutes away, so when I ordered one [the company] invited me over to have a look around. Its speciality is seam welding, so when we needed welded bladders to go into the sole of the boot they were an obvious choice.

"And then about three or four months ago, [the supplier] came up with a new idea themselves, for hot and cold therapy for muscle injuries." As a former rugby player, this is something that Nigel is very familiar with. "We happened to have done some work on this ourselves, so I went and retrieved our previous material. The idea is the product uses a sleeve attached to a control box that contains hot water in one chamber and ice water in another, and you put it onto the affected part and it applies pulsing pressure and alternate heat and cold. Basically, it's a more effective replacement for Tubigrip and a bag of frozen peas, which is what we used to do for injuries. This isn't something that is going to make a huge difference to society, but it can fund things that will make a huge difference and that is what we are really interested in."

Those looking for connections would be tempted to think that electricity might be the link between all of Morgan's products. But even this would be a mistake. Morgan's latest launch is a test for pre-eclampsia, a condition connected with high blood pressure that occurs in pregnancy and can be life threatening. "Our financial director was at a dinner party with a doctor's brother; they got chatting, and the doctor was a rheumatologist who had done a very small clinical trial on using uric acid as a biomarker for preeclampsia in pregnancy. He had managed to prove his theory but needed help in progressing the idea," Clark said.

This concept has now been developed into a test that Morgan is developing under the name Salurate, a bioassay that works by inducing a colour change in a test swab that reacts to a saliva sample. The patient then takes a picture of the swab on a smart phone and sends it to a clinician; a positive test indicates a need for close monitoring.

Clark believes that Salurate can be a lifesaver. "We are not purely driven by money here," he said. "We are a family company and we fortunately make good money. Our overriding drive is to produce products that will generally make a difference."

Another potential lifesaver is a battery-operated inflatable incubator concept that won its inventor, James Roberts, the James Dyson award in 2014 when he was a student at Loughborough University. Morgan hopes to have this on the market within the next two years. (9)

interview | henry white



Perfecting this sporting life

BAE Systems' lead for its partnership with UK Sport is focused on those all-important marginal gains. Andrew Wade reports

t the 1996 summer Olympics in Atlanta, Great Britain took home just a single gold medal, the ever-reliable coxless pair of Steve Redgrave and Matthew Pinsent topping the podium. Last summer in Rio, Team GB collected a total of 67 medals, 27 of which were gold. The

dramatic improvement can be attributed to many factors, not least the huge amounts of lottery funding that UK Sport has funnelled towards Olympic athletes. Recently, however, technology's role in the UK's sporting success has become more pronounced.

For the past eight years, BAE Systems has worked with UK Sport as its official research and innovation partner, employing engineering and technology to eek out marginal gains across a range of Olympic and Paralympic events. Hundreds of athletes have benefitted across more than 30 sports, including track cycling, BMX, wheelchair basketball, bobsled and canoeing. The variety of challenges is one of the things that keeps the engineers on their toes, according to Henry White, BAE's lead on the UK Sport partnership.

"I think one of the reasons they approached me was because of the background I had with BAE Systems' Advanced Technology Centre," he told *The Engineer*, "looking at a lot of short-term projects that would develop demonstration-type equipment, rather than the full-blown product development that we get in, say, military aircraft or the naval ship side."

White's background is photonics, but his current role puts him across the full gamut of engineering, from materials and mechanics, to sensors and virtual reality. One particularly lauded piece of equipment developed under the partnership is the cycling ergometer. Britain's medal haul in recent Olympics has been massively bolstered by its track cycling team, with athletes such as Chris Hoy, Victoria Pendleton, Laura Trott and Jason Kenny becoming household names. The recipe for velodrome success has had many ingredients, but having a machine to replicate conditions on the track has been a crucial one.

"It was used in the build-up to the 2012 London Olympics," said White. "Chris Hoy was very enthusiastic about it at the time as well. It's been very successful for them in terms of the way they feel they can represent some of the forces you get on the velodrome that you can't do with other training systems."

One of the device's key advantages is that it can be customised for individual riders. It essentially consists



"We're able to use this partnership with UK Sport to publicise technology as a whole, at a level that's attractive to the younger population"

of a bike with a huge flywheel at the back, which has adjustable blades capable of providing a wide range of resistance.

"That's linked in with the cycling system so that you can release that energy at different times on the stroke. You see them do the cat and mouse at the top of the banks, then all of a sudden they'll make a big effort. It's about being able to simulate that, at the right time, on the right banking."

In many cases, BAE Systems' input involves simply improving existing concepts, whether through the introduction of new materials or supplementary technology. It has adapted optical sensors from UAVs to help improve the trajectory of BMX riders, and used its wind-tunnel facilities – ordinarily the preserve of military jets – to help bobsled teams and wheelchair athletes improve their body position and technique.

"We can do a lot on the training apparatus, because obviously there's a huge amount of flexibility on that," said White. "Often the equipment they actually use in the sports themselves is very proscribed.

henry white

CareerCV

Henry White Technical lead for BAE Systems UK Sports Partnership

Education

· Studied physics at the University of Manchester, specialising in photonics

Career

- Joined British Aerospace in 1983 as a principal scientist at the company's Filton facility, becoming a senior principal scientist at **BAE Systems in 1999**
- Named group leader for Photonics Group of BAE Systems' Advanced Technology Centre in 2010
- Promoted to lead technologist for electro-optics and photonics within BAE's Military Air and Information unit in 2015
- The same year saw White made engineering lead for BAE Systems' technology partnership with UK Sport

Winter Olympics, and also Tokyo [Summer Olympics 2020]," White said. "One area that we've moved into is not just looking at people, but looking at horses in equestrian events that need technology as well."

The benefits of all this for UK Sport are glaringly obvious, but it's perhaps less clear what BAE Systems gets out of the deal. However, White is quick to point out that there are several areas where the partnership benefits the company, as well as the nation's athletes.

"We're able to use this to publicise technology as a whole, at a level that's attractive to the younger population. Helping to increase that potential pool of engineers around the country is great. If some of them come here to BAE Systems that's helpful, but actually we need engineers within the supplier network as well."

White said there has also been technology transfer back into the company via some of the sporting projects. Prototyping and pushing for immediate gains is fundamentally different from BAE's bread and butter of long-term, large-scale defence contracts. That paradigm shift helps breed creativity and delivers offshoots back into the core business.

"We have a relatively light process on it, so we use a lot of the apprentices and graduate engineers in the company on it as well. It's proved to be a very useful role for them to experience project lifestyles with a short turnaround, and to be aware of technology from a lot of the different sites."

Furthermore, those working on the projects often see the fruits of their labours played out on national television within months, rather than the decades some military programmes can take.

"There could be people who've just started work on the next submarine, for example, and they think 'I'll be retiring before I see this'. The enthusiasm they get from working on something they can see the benefits from in a relatively short timescale has been quite important as well."

Sometimes there are variants that we can influence on that as well, but it's in the training where you think 'actually, this can be improved'.'

As the partnership with UK Sport has evolved, so too has the technology. Ahead of last summer's games, BAE provided Team GB with a number of virtual reality simulations, accessible on smartphones, as well as VR headsets. Known as VR-Vantage, the project was designed to help athletes familiarise themselves with the big stage before setting out for Rio.

Olympians and Paralympians used the technology "to experience venues, the village beforehand, but also courses such as the cycling course for the triathlon", White explained. "It was used in the clay-pigeon shooting area as well. I had never really watched clay-pigeon shooting before, but after we'd been involved with them, and watching them have much better success than in other Olympics - there's many reasons why that would've been, but they're all paying a lot of attention to the small things they can do to improve."

Marginal gains - the pursuit of multiple minute advantages with the aim of overall improvement - have become the hallmark of top-level sport in recent times. The benefits of this approach for Team GB, in combination with the cut-throat manor in which lottery money is allocated, are there for all to see. It's really only on the athletics track, where figures such as Jess Ennis and Mo Farah have captured the imagination, that BAE Systems can't claim a contribution to the success.

"Where it's hard to apply some of the technology is with simple running," said White, "but I'd probably say that all the sports where there is some technology we've had discussions or had some input already, even if it's just advice or testing equipment. You take carbon-fibre equipment you've got hockey sticks, you've got kayaks, you've got windsurf masts. Just understanding the performance of all those things is important."

With the current four-year cycle coming to an end this year, discussions with UK Sport are under way to renew the partnership. However, the nature of the planning involved for Olympic sport means BAE engineers are already helping Team GB prepare for upcoming games.

"Even on the current funding we're looking at technologies for the Pyeongchang [South Korea]

bobsleigh team

inside BAE's

wind-tunnel

facility

created underboot attachments for Britain's speed skaters

> 03 BAE's cycling eraometer helped propel Team GB's cyclists to medal success

01 Members 02 BAE of Britain's







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scifi eye | jon wallace



Deadly thrills and spills way up high

Novelist Jon Wallace considers the science fiction implications of engineering stories that have caught his eye. This month, the everlasting appeal of the flying car



or decades the idea of the flying car has helped shape our vision of the future, every bit as much as the robot and the rocket ship. For *Popular Science* enthusiasts of the 1940s, 1950s and 1960s, the air car would be the inevitable culmination of aeronautical and automotive engineering. Even Henry

Ford said flying cars would come. Where the automobile had granted the masses freedom from the train, we would inevitably gain independence from aircraft.

Even now, despite a catalogue of failures, efforts to realise the dream continue, as if the 21st century feels obliged to meet the expectations of the 20th. Most attempts are unwieldy mutations, but engineers gamely plug away at the challenges, delivering chimera after chimera, with a host of new projects on the block: John Brown's Carplane, Airbus's Vahana, Urban Aeronautics' Cormorant and Japan's Skydrive, to name but a few. Uber, ever free with a headline-grabbing press release, promises a fully electric VTOL taxi in five years.

The Engineer's readers are largely unconvinced about the utility of such projects. A recent poll found the majority believed urban aerial transport to be unworkable. Comments online highlight the environmental and infrastructure challenges of flying vehicles – besides the limited ability of some to master the ground vehicles they already possess.

Why then, does the dream endure? Science fiction's approach to the subject is instructive. The flying cars of scifi have tended to serve as the vehicle of the outsider: *Back to the Future*'s retrofitted Delorean; Corbyn Dallas's battered yellow cab in *The Fifth Element*; and Dave Lister's stolen Hopper in *Red Dwarf.* Such devices help establish their owners as outlaws. Doc's machine lets him roam free of the laws of physics; Dallas's cab allows the alien, Leelu, to escape the clutches of Earth's government; Lister's stolen Hopper taxi lets him scrape a living on the fringes of Mimas spaceport.

It's this promise of living unleashed that fires the imagination. Inventors and scifi writers care about the flying car precisely because of its potential to free us from the grip of regulation; from the watchful "The chaos of a sky buzzing with air cars offers science fiction writers scope for tales of outlaws and fugitives"

Jon Wallace

The flying car may promise a chaotic future but it shouldn't be counted out

eyes of a speed camera, and from the cattle-truck conditions of check-in and economy class.

The chaos of a sky buzzing with countless air cars offers science fiction writers plenty of scope for more tales of outlaws and fugitives. How, we should ask, would ubiquitous flying cars affect the face of future cities?

A story could take place in a future London, where thoughts of third runways are as dead as those of 'Boris Island': Heathrow is an abandoned boneyard, where legions of unemployed pilots, stewardesses, check-in staff and baggage handlers camp among the wrecks of their once mighty jet liners. Their services no longer required, their status plummets, and the former air workers pick a living wandering a new skyline of rooftop landing pads, bothering their one-time passengers with offers to wash their windscreens.

In this new world the average family can even traverse oceans with ease, as a new generation of service stations bloom at sea, catering to the air car diver's fuel, food and entertainment needs: converted tankers make air car parks of their decks and restaurants of their holds.

One enterprising captain turns his ship into a floating arms fair, smugglers den and casino beyond the reach of the law. The world's governments tolerate his operation, until he begins dredging



and building his own chain of islands in the north Pacific, declaring himself king of a nation state. Edging too close to US territory, a fleet is dispatched to conquer his upstart nation. Our king sends waves of air cars to meet the jet fighters, resulting in a bloody second battle of Midway, and ending his mad dreams of empire.

Indeed the air car's potential to facilitate illegal activity may well stifle development before it's born. Governments will have no love for a vehicle that easily traverses borders unchecked. A story could see a band of 'good old boys' wage a new Prohibition-style border war, using souped-up flying cars to smuggle contraband over the Great Wall of Trump. Just as bootleggers spawned Nascar, so their vehicles spawn a new era of racing, a kind of steeplechase motorsport, offering spills and thrills to a whole new generation.

The flying car may promise a chaotic future, but we shouldn't count it out yet. Why, after all, do people buy Ferraris? The image of freedom, speed and danger is at least part of the allure. 'Flight mode' would unlock a whole new world of deadly thrills. Expect queues at your local showroom.

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

Real measure of autonomy

Chris Pickering puts Tesla's much-hyped Autopilot technology to the test on the roads around London Heathrow



or almost as long as people have been hypothesising about the cars of the future there has been the dream that these machines would one day drive themselves. It's a vision straight out of *The Jetsons*, but now, of course, it's here. Or at least very nearly. In the absence of a futuristic Utopia we took to the roads around Tesla's London Heathrow store to

sample the brand's latest offering, the Model X. Like that of its technologically identical saloon counterpart, the Model S, this car's Autopilot system is technically defined as an SAE Level 2 driver aid. That means it can accelerate, brake and steer for itself under certain conditions, but you can forget **01/05** Under certain conditions the Model X can accelerate, steer and brake for itself

02/03 The view through the largest windscreen ever fitted to a production car

04 The car will cover around 250 miles on a full charge

any notions about sliding into the passenger seat and catching up on some emails.

Tesla is totally upfront about this fact, although it does say the hardware is ready to support full autonomy as and when the software calibration – and presumably a certain amount of legal wrangling – allows. Right now, you're not allowed to take your hands off the wheel for more than a couple of seconds or the car's electronic brain will shut down the Autopilot. Think of this, then, as a highly sophisticated cruise-control system.

The Model X calls upon a formidable array of transducers to make sense of its environment. Eight cameras provide full 360-degree vision up to a range of 250m, while 12 ultrasonic sensors can detect both hard and soft objects at up to 5m. There's also a forward-facing radar system, which is able to penetrate rain and fog; it can even bounce signals underneath the car in front to see what's happening further up the road.

The name (and indeed the spec sheet) might sound like they've been pinched from a passing spaceship, but the Tesla is surprisingly easy to get to grips with. You gaze out through the largest windscreen fitted to any production car, with a subtly elevated view over the other traffic. Despite its considerable dimensions – longer and wider than a Range Rover – the Model X is straightforward to place on the road. There's a single-speed transmission, so you simply pick forward or reverse and go. With the regenerative braking turned up your foot rarely needs to leave the accelerator.

Once you're over 20mph the Autopilot can be engaged by pulling the cruise-control stalk. The system will only take over if it can detect white lines on both sides, and there's a graphic in the dashboard display that shows you exactly where the vehicle sits within its lane. This also shows the proximity of other traffic, which provides reassuring confirmation the car is aware of its surroundings.

The next thing you notice is the Tesla's positioning. It's









almost certainly more accurate than that of a human driver, but it is a little disconcerting initially when you realise the car's idea of where it should sit on the road doesn't necessarily tally with your own.

We followed the gentle curves of the M4 for a few miles, with smooth inputs and pinpoint precision, before trying out the Tesla's party piece. Indicate to change lanes while in Autopilot and the car – if it deems it safe – will do so for you. There's a slight lull and then a gentle push as if a giant hand were guiding you across the carriageway. While the rate of yaw is probably comparable to that of a typical human driver the steering input is so progressive that you're not really aware of a point where the car starts to rotate. It's a little eerie the first time.

Soon, though, it all becomes second nature. As with other adaptive cruise-control systems, the car will

"There's a slight lull and then a gentle push as if a giant hand were guiding you across the carriageway" accelerate or brake to reach your chosen speed, and you can also specify the gap it leaves to the vehicle in front. Meanwhile, the computer keeps a watchful eye out for anyone cutting into your lane. As you can imagine, this happened a lot during rush hour on the M4, and yet the Tesla remained totally unflustered.

It's also worth pointing out that the Model X is a very respectable steer when choice or necessity compels you to take control. Despite a hefty 2,467kg kerb weight, it handles with aplomb, while the performance on tap is faintly surreal for a large SUV, with a Ferrari-bating 3.1-second 0 to 62mph time in 100kWh form. Driven more sedately, we're told it will cover around 250 miles on a full charge (the official NEDC figure is 336 miles) and cabin refinement is up there with the very best combustion-engined opposition. The car of the future? It's certainly a major step.



Drives all pumped up for an overhaul of hotel hot water

Helping to reduce demand and wear and tear among a group of pumps. Supplier: ABB



When the Daresbury Park Hotel & Spa was acquired by the Britannia Hotel Group in 2015, it became apparent that the hot water pumping arrangement was in need of overhaul.

PressBoost found three large pumps operating in a duty-standbystandby configuration that were suitable for the hotel.

Although the pumps could provide hot water to the hotel, the lead pump was suffering from excessive wear.

"Duty-standby-standby... means that most of the time pump number one was doing all the work, while pumps two and three were mostly idle," said Antony Chesters, senior engineer at PressBoost.

PressBoost also discovered that while the motor driving the lead pump had been fitted with a variable-speed drive (VSD), it was no longer working so the pump ran at full speed regardless of demand, putting extra strain on the motor.

PressBoost installed a 7.5kW ABB drive on each of the three pumps to adjust the speed of the pumps depending on demand. When less hot water is required, the flow of energy from the motor to the pump is reduced. This has enabled the hotel to cut the energy it uses to supply hot water by 53 per cent.

The system was also reconfigured to work on a duty-assist-standby arrangement to reduce wear on the lead pump.

"Should demand exceed pump one's capacity, the second pump switches on automatically to assist the lead pump. However, regardless of demand, the pumps switch over every 24 hours in order to spread demand and reduce wear on the lead pump," said Chesters.

The VSDs keep water pressure constant at 3.5 bar, which also helps to reduce wear on other parts of the hot water system.

The ABB drives were installed as part of a control panel and are programmed via a PLC. Were the PLC to fail, a fail-safe programme switches the system to a singlepump, fixed-speed operation.

Plastic bearings are a real lift

Bearings go to work on lorry tail-lift platforms. Supplier: Igus

Palfinger makes 15,000 lift platforms each year for vehicles that can be driven anywhere in the world, and it uses Igus plastic plain bearings on its tail lifts for reasons that will become apparent.

"A tail lift is located just behind the lorry, which is a harsh and difficult environment – just about everything rusts here," said Eike Rulfs, head of design and development at Palfinger.

This is problematic because goods cannot be delivered if the function of a lift platform is not guaranteed. Furthermore, a malfunctioning tail lift on an ambulance could compromise

the safe movement of patients. There are 12 bearing points on each hoist of a lift platform. If metallic bearings are used, it is necessary to regularly lubricate them so maintenance-free properties and corrosionresistance were required for components in a new project.



In Britain, there is a stipulation that patients are put into an ambulance with a lifting aid. The vehicles are box vans with twin wheels on the rear axle and a vehicle weight of five tons. For added protection from corrosion, Palfinger's customer opted to replace the conventional steel bolts on the lift platform with stainless steel.

The new material Iglidur Q290 from Igus was launched at the right time for the construction of the lift platform of the ambulance. Like all plain bearing materials made of Igus high-performance plastics, it is optimised for friction and wear, and is self-lubricating.

The compatibility of the plain bearings was crucial to Palfinger: the bearings should fit into existing housings of the structure; Igus therefore created a custom bearing dimension that was available exclusively to Palfinger.

Iglidur Q290 also has excellent friction and wear values on stainless steel shafts and it fits with the new Palfinger bolts. The material is well suited for forces up to 55MPa and readily accepts edge loads.

Bearings join movement for marine-energy device

Project involves roller bearings, ball bearings and one-way clutches. Supplier: Schaeffler UK



Schaeffler UK is supporting the development of a novel Britishdesigned marine energy device that generates electricity from any form of movement.

Developed by WITT Ltd, the WITT (Whatever Input to Torsion Transfer) is a six-degrees-of-motion energy harvester that uses two pendulums connected to a flywheel to generate electricity from movement in any direction. This movement causes the two pendulums to swing.

The pendulums are attached to a shaft, which turns a flywheel in one direction. The flywheel is connected to a generator, which produces electricity. Effectively, this means the device is able to generate electricity from sea, river, tidal or wind energy, and from the movement of humans or animals.

WITT Ltd is developing a 200W

marine version of the device. In this version, the WITT energy device is fitted into a sealed 1.5m unit. The first working prototypes have been tested on a shaker table at Southampton University and sea trials will follow.

Schaeffler UK is supplying the bearings for the marine WITT, including roller bearings, ball bearings and one-way clutches.

Stewart Davies, principal applications engineer at Schaeffler UK, said: "There are approximately 25 different bearing locations on the 200W marine WITT device, some of which are bespoke in order to meet the restricted design envelopes in the application."

As the marine WITT is a totally enclosed, sealed unit, Schaeffler UK was able to select standard bearings for most locations, which helped to minimise the cost per kilowatt of the device.

To help optimise the design, Schaeffler used its own design and calculation software to model the complete transmission system, including gears, bearings, flywheel, one-way clutches and shaft. This enabled the loads on the bearings to be calculated. In turn, this helped to optimise the design of the WITT transmission system. (a)

Modular aluminium profile system takes centre stage

Packaging system is part of automation division expansion. Supplier: mk Profile Systems

German company Steffes Prüf- und Messtechnik wanted to develop an innovative packaging system to expand its automation division and looked to the mk Technology Group to provide suitable products. Due to space limitations the customer required a height-adjustable and compact system. For several decades Steffes has used the mk aluminium profile system as the basis for all of its machines. Experience has

achines. Experience has taught it the benefit of using the components and modules of this modular system as they can easily and quickly be changed or adjusted at a

> later date. mk was able to provide a design that met the requirements both flexibly and economically. The S-PACK-PAL-T is a fully automatic

machine for packaging various empty containers (e.g. bottles, cans, canisters) in cardboard trays and subsequent palletising of the trays on a pallet. In addition to being robust, safe and easy to use, the machine needed to have a packing height of 3m. A compact, box-shaped frame was necessary so that it can be transported easily on a lorry or a maritime

container. The required height of 3m turned out to be a major obstacle as the ceiling height on the assembly area at Steffes did not facilitate the option to build such a tall machine. The answer was to build a telescopic frame that could be extended by a further 1.5m.

It was not only the telescopic frame of the system, but also components such as conveyors, frames and guarding, doors, windows and the gripper for the cardboard trays that were built from the mk system.

After the concept of the packaging system was fully developed, the first prototype was put into service by the client in a semi-automatic version. This was considered a huge success and two more machines followed as a fully automatic version.

Giving birth to digital twins

Simulated asset twins aid performance. Supplier: Ansys

General Electric and Ansys are collaborating to create simulated digital twins of operating assets that enable companies to improve performance and productivity.

Digital twins are virtual representations of individual pieces of equipment. By taking the sensor data from industrial machinery and combining it with simulation, operators will be able to perform enhanced diagnostics and prognostics, improving maintenance and overall productivity.

"Pairing physics and analytics models via the digital twin is essential to providing our customers with the 360-degree insights they need to create competitive advantage in a rapidly changing world," said Eric Bantegnie, Ansys vice-president. "We are excited to be taking another step forward in our long-standing partnership with GE."

General Electric and Ansys first teamed up to create a digital twin in 2015 when developing a 2.7MW circuit breaker, and GE has previously used the technique to design more efficient wind turbines. The new collaboration will see Ansys integrating with GE's Predix platform to provide digital twin services across a wide range of industries. The companies claim that scaling digital twin solutions from the edge to the cloud will enhance the value of Ansys



Getting expansive for virtual reality

Company aims for virtual reality at a large scale

and at a low cost. Supplier: Dassault Systèmes



Dassault Systèmes, the parent company of CATIA and SolidWorks, is expanding its virtual reality capabilities by adding support for the HTC Vive Business Edition.

The European multinational's 3DExperience platform was already compatible with the HTC Vive VR system, and the two companies have been collaborating on VR-led 3D design. According to HTC, the Business Edition of Vive will feature "additional services adapted for business and commercial environments". These include a bespoke commercial warranty, as well as a dedicated business support line.

"Virtual reality has transcended consumer applications and is now establishing its strategic value for more informed decision-making in business," said Olivier Ribet, vicepresident of High-Tech Industry at Dassault Systèmes.

"Virtual reality paired with our experiences on the 3DExperience platform provides a new and intuitive way to push the boundaries of creativity. Designers and engineers can facilitate the convergence of product aesthetics and technical requirements while a marketer can better influence the user experience for more personal and emotional impact."

According to Hervé Fontaine, HTC's vice-president for virtual reality enterprise and business development, the commercial edition gives access to multiple Vive units – something not offered to ordinary consumers.

"The Vive Business Edition allows Dassault Systèmes' customers to use virtual reality at a large scale at low cost," he said. "With the Vive's unique laser tracking system providing sub-millimetre precision and very low latency, it is an ideal fit for Dassault Systèmes' CATIA applications users who can now check their work in real time as they modify their design."

Dassault announced this latest collaboration with HTC at the Consumer Electronics Show in Las Vegas in January.

Modelling and simulation arrives at the platform

Powertrain Blockset offers up fully assembled reference application models. Supplier: MathWorks



MathWorks has launched a new product called Powertrain Blockset, designed to support automotive and controls engineers in powertrain modelling and simulation.

According to the company, the new platform provides fully assembled reference application models of gasoline, diesel, hybrid, and electric powertrains. It also includes a component library for simulating engine subsystems, transmission assemblies, traction motors, battery packs and controllers, while also featuring a dynamometer model for virtual testing.

Powertrain Blockset provides a standard model architecture that can be reused throughout the development process. It can be used for design trade-off analysis and component sizing, control parameter optimisation, and hardware-in-the-loop testing. Engineering teams can customise models using components in a reference application with their own data, or by replacing a subsystem with their own model.

"Automotive teams that are deploying model-based design often look for a starting point for building system models and applying these models to design and testing," said Wensi Jin, automotive industry manager at MathWorks.

"Developing a system model from the ground up requires significant effort and engineers with specialised skills. With Powertrain Blockset, these engineers can take advantage of a maintained, well-documented, and open set of models that can be customised to their needs."

Powertrain Blockset provides mapped and dynamic combustion engine models: mapped and dynamic. Mapped engines represent macro engine behaviour as a set of look-up tables (brake torque, fuel flow, air mass flow, exhaust temperature, efficiency, and emissions) as functions of commanded load and measured engine speed. Dynamic engines decompose engine behaviour into individual component models that account for engine dynamics.

A set of prize assets for the Industrial Internet of Things

Awards success comes on the back of expansion of company's IoT 'ecosystem'. Supplier: PTC



Boston-based PTC has been named Industrial Internet of Things Company of the Year at the IoT Breakthrough Awards.

The awards were judged by an independent panel of experts representing a cross section of the IoT industry. According to PTC, the recognition comes on the back of a successful 2016 that saw it add a significant number of new customers and partners to its IoT 'ecosystem', as well as improved integration of industrial connectivity and machine-learning technology into its ThingWorx platform. Last year also saw the company add a new augmented reality (AR) component to its product portfolio.

"We are excited to recognise companies such as PTC that are

playing such a substantial role in advancing the IoT industry," said James Johnson, managing director of IoT Breakthrough.

"The Industrial Internet of Things Company of the Year award category featured nominations from the top IoT vendors in the industry, and we acknowledge and congratulate PTC for breaking through to achieve this recognition and continue its leadership position."

PTC also took home the award for Industrial IoT Solution of the Year for its Kepware KEPServerEX industrial connectivity software. KEPServerEX is designed to connect, manage and monitor automation devices and applications that enable Industry 4.0.

"PTC is dedicated to providing the IoT platform of choice for companies building solutions for the industrial space, from custom applications that monitor a group of existing assets to remote service offerings that lower the cost of traditional maintenance," said Kevin O'Brien, vice-president of IoT partner sales at PTC.

"These awards are yet another validation of our efforts, and we remain committed to helping companies achieve new business value through IoT solutions." (a)



3D PRINTING CNC MACHINING INJECTION MOULDING

Transforming water testing

When Danish company SBT Aqua needed to prepare its groundbreaking water-analysis technology for production, it turned to Proto Labs in the UK. Using all three of the company's services, 3D printing, CNC machining and injection moulding, the Scandinavian entrepreneurs were able to develop and test their revolutionary design quickly yet thoroughly.

SBT Aqua's innovative process, BactoFlow, speeds up the detection of pollution in water: its simple ambition is to help create a world where everyone can drink water, knowing it's clean and safe. Today, the microbiological quality control processes used are slow and expensive. For example, to analyse water guality and test for bacteria, samples are collected manually, then incubated in a laboratory for three days before the results are received. With SBT Aqua's system, a new type of automated sensor continuously samples the water, measuring bacteria levels and alerting the company employing the technology immediately if contamination is detected. BactoFlow's sensor works through a system of impedance flow cytometry

- which means it uses an electric field to detect bacteria without pre-treating or incubating the water sample. The electric field probes the electrical properties of particles in the water, and the results are compared to a database to determine if the particles are bacteria.

Combining three services for rapid results

SBT Aqua planned to use injection moulding to mass-produce its sensors. But first it used 3D printing to refine the design, as the ease of creating prototypes using additive manufacturing makes it the fastest method for perfecting parts. The company then utilised CNC machining to develop highly accurate models, which helped predict



exactly how the finished product will look when injection moulded.

Being able to use all three of Proto Labs' services has made a big difference to the progress of BactoFlow's development. As Gustav Skands, CEO and founder of SBT Agua, explained, "The short turn-around time offered by Proto Labs, in conjunction with a strong support team helping to deliver the parts, was extremely valuable. To put this into context, Proto Labs can produce and deliver parts guicker than if we used a local workshop! The other main advantage was the quality assurance provided by Proto Labs. With each part design-checked before production, we had the benefit of the company's 20 years' experience to identify any improvements or tweaks the design needed. This is extremely valuable to us; the quality and reliability of BactoFlow are crucial to ensure it fulfills its potential to revolutionise contamination detection in water."

Ready for a healthier future

Encouraged by the prototyping experience, SBT Aqua will be using Proto Labs for injection moulding when BactoFlow goes into full production. Working with Proto Labs has helped SBT Aqua keep costs down: by perfecting the sensor design in advance, the company saved several months of production time and gets BactoFlow to market as quickly as possible.

Quick on the draw

Advances in 3D-printing technology continue to drive its use as a rapid prototyping tool. Helen Knight reports

> hen McLaren Racing announced a four-year partnership with 3D printing specialist Stratasys earlier this year, it was a sign of motorsport's increasing reliance on rapid prototyping technologies.

Being able to rapidly model, build and evaluate new components is an $% \left({{{\rm{D}}_{\rm{B}}}} \right)$

invaluable capability in a fast-moving organisation such

In Formula One in particular, cars are adjusted between each race in a bid to squeeze even a fraction more speed out of the vehicles.

This means McLaren must produce prototypes and one-off components extremely quickly, said Andy Middleton, president for EMEA at Stratasys.

"A Formula One car is essentially a prototype," according to Middleton.

"There is a huge requirement for adjusting that car from race to race, so McLaren is pushing the boundaries of prototyping and looking to produce what are essentially one-off components in advanced materials such as carbon fibre."

But it is not just motorsport where companies are increasingly relying on rapid prototyping technology. Indeed, according to a forecast by analysts Research and Markets, the global market for rapid prototyping materials is expected to reach \$903.8m (£724.8m) by 2021.

Stratasys itself has 32,000 3D printers installed throughout Europe, of which 80 per cent are used for rapid prototyping, according to Middleton.

Industrial awareness of the benefits of 3D printing for

"McLaren is pushing the boundaries of prototyping and looking to produce what are essentially one-off components in advanced materials"

Andy Middleton

01 The quality of 3D-printed components has improved massively in recent years *Image: CDP*

rapid prototyping has grown considerably in recent years, while the technology has also improved, he said.

"When I joined Stratasys we had one material for our PolyJet [inkjet printing] technology, which was grey in colour and had a thermal stability resistance of 32°C," he said. "That meant, basically, that if you put it on your windowsill on a sunny day the part would be larger in the afternoon than it was in the morning," he said.

Now, printed parts are able to withstand temperatures of around 120°C, added Middleton. "That means a huge step forward in accuracy, and a huge step forward in the potential to use a printed part for functional testing."

Different materials can now be mixed and printed on the fly. A single prototype can also be produced with different properties at various points in the part.

"If you think of a sports shoe, you could have a rubber flexible sole with a rigid upper, within one piece," said Middleton.

The colour and finish now achievable using 3D printing technologies have advanced considerably, according to Philip Hudson, managing director of software and solutions for additive manufacturing specialist Materialise.

The industrial design agency Layer recently won an Innovation by Design Award for its GO wheelchair prototype, the world's first 3D-printed wheelchair. GO was designed >>



>> as a proof-of-concept by the company's research division, LayerLAB, in collaboration with Materialise. The designers wanted to develop a prototype that would look and function as much like the final product as possible.

So specialists at Materialise used the company's Mammoth Stereolithography machine to print the smooth but intricate structure needed for the wheelchair's seat. The chair's footplate was built in aluminium, using metal 3D printing.

"A really A-class surface is now possible with additive manufacturing, and that is a massive step forward," said Hudson. "So functional parts now become both functional and cosmetic."

Many of the recent advances in the final-finish quality of 3D-printed prototypes have come from developments in pre- and post-processing tools rather than the additive manufacturing machines themselves, said Hudson.

"Customers end up staying with 3D printing to produce the final part because there is no reason to move on to anything else"

Philip Hudson

02 Increased speed helps prototypes to be built more quickly *Image: CDP*



In the past, printed prototypes would have required time-consuming finishing steps, such as sanding, to achieve the desired appearance, he said. But the time taken can now be reduced, such as with the use of pre-processing software tools to better orient the part before printing.

"There are customers who come to us to rapid prototype a product, thinking that they will then move on to traditional methods of manufacture," said Hudson.

"But they end up staying with 3D printing to produce the final part because there is no reason to move on to anything else."

Some developers now use rapid prototyping as a way to demonstrate that 3D printing is a suitable process for manufacturing the final product, he added.

Digital services company Atos recently worked with Materialise to reinvent a titanium insert used in satellites and other aerospace applications, for example. The inserts, which are often used as mounting points to attach devices to satellites, are conventionally brick-shaped titanium or aluminium parts, built by machining.

However, by using metal 3D-printing technology the companies were able to design and build a titanium insert with an internal lattice structure. This reduced the mass of the part by two-thirds, from 1,454g to 500g, while also reducing its vulnerability to thermo-elastic stresses.

The use of 3D printing for rapid prototyping applications is also becoming more accessible as newcomers to the market offer simpler, lower-cost devices, said Mark Cocking, research development engineer and specialist in additive manufacturing at the Advanced Manufacturing Research Centre (AMRC) with Boeing at the University of Sheffield.

"You don't always want to dial in settings and tolerances to the nth degree for a quick test," said Cocking. "So the up-and-coming players in the market are allowing us to develop things a little bit faster and more cheaply."

The speed of many 3D-printing technologies has improved in recent years, enabling prototypes to be built more quickly, according to Karl Hewson, design engineer at the Cambridge Design Partnership.

Previously, parts could have taken three to five days to be produced, whereas they can now be in a developer's hands overnight, or even the same day, said Hewson.

Among the various 3D-printing technologies used by Cambridge Design Partnership, the company has recently been working with a digital light processing (DLP) printer, produced by EnvisionTEC.

The technology projects light onto photopolymer resin to harden it, and is capable of producing very accurate parts, with crisp corners and edges, said Andrew Stockdale, design engineer at Cambridge Design Partnership.

"Effectively, it projects the whole build platform in one go, layer by layer, instantly," he said. "So that allows the 3D print to almost grow out of the vat."

The use of 3D-printing technologies for rapid prototyping has increased considerably in recent years, and this looks set to continue as more developers enter the market, reducing the cost of devices and materials and making them accessible to a wider range of companies.

And with companies such as McLaren pushing the limits of technology, the range and accuracy of prototype parts built with 3D printing are likely only to improve.

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Moving towards Southern shores

Southern Manufacturing & Electronics has been rescheduled to run in late March, which, it is hoped, will boost attendance even further



outhern Manufacturing & Electronics returns to Five, Farnborough, on 21-23 March 2017. The 2016 show brought together around 800 exhibitors from almost every sphere of engineering and manufacturing. A similar number are expected for 2017. The rescheduling of the exhibition to late March should be welcomed by both visitors and exhibitors alike. Significant on-site developments at Five aimed at improving access, combined with lighter evenings, and – hopefully – less wintery weather will make life a little easier for visitors, and,

it's hoped, help push the attendance figure north of last year's record 8,700.

The event is well established as one of the most important showcases for industrial technology in the UK. Divided more or less equally between electronics and manufacturing, and including a specialist automotive and aerospace zone, purpose-built in the 18,000m² venue, the show plays host to an enormous variety of manufacturers, vendors and service providers. Among the key attractions for





01/02 The event is well established as an important showcase for technology in the UK

visitors in 2016, components and OEM parts figured strongly, alongside machinery and other hardware. Many of the UK's leading machinery vendors, among them Matsuura, XYZ Machine Tools, Haas Automation, Bystronic, Yamazaki Mazak and others, run continuous live demonstrations of the latest hardware, giving visitors an excellent opportunity to compare offerings from different manufacturers side by side. Subcontracting, including electronics assembly and manufacturing, was also a top goal for many - over 45 per cent of visitors came searching for service vendors within these fields.

Conveniently located adjacent to the M3 in Hampshire and well served by public transport, the show is an outstanding opportunity for engineers from all sectors to see the latest industrial technologies and meet a wide range of companies in a single. time-efficient visit. Specialist areas such as the production equipment, machinery and subcontracting zones make it easy for visitors to locate firms of interest with the minimum of effort. Technology trails highlight companies with particular expertise in areas such as aerospace, medical technology and defence. There are no physical boundaries between any of the show areas, and the ability for visitors to wander freely between them is frequently cited as one of the best aspects of the show as it often leads to visitors encountering firms and products they hadn't considered before. This is particularly true of many international firms exhibiting at Southern Manufacturing & Electronics, who are rare visitors to UK shores.

In addition to the exhibition and display areas, the free seminar programme is a hugely popular aspect of the show. The comprehensive programme runs over three days in two theatres, focusing on manufacturing and electronics, respectively, and addressing key subject areas across technology, innovation, business management, design and the most recent manufacturing legislation. Free access to such high-calibre technical and commercial insight is yet another reason to make the trip to Farnborough.

Entry to the exhibition and the technical seminars is free, and Five Farnborough provides ample free car parking. There's straightforward access by road from the M3 or by public transport. A complimentary shuttle bus connects the show and both of Farnborough's railway stations. To apply for tickets, simply go to www.industrysouth.co.uk.

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Changed landscape for maintenance

The Internet of Things (IoT) is having a marked impact on the way that products are monitored and repaired out in the field



imes are changing in the maintenance industry, as increased digitisation of industrial environments transforms the way that products are made and serviced

Greater connectivity is providing companies with far better knowledge of the condition of their assets, bringing the potential for smarter factories based on preventative maintenance methodologies.

The Internet of Things (IoT) is also having a marked impact on the way that products and equipment are monitored and repaired out in the field, leading to the

emergence of new service-based business models using cutting-edge technology such as augmented reality and wearables.

These are just some of the forward-looking trends that will be discussed at Maintee 2017, the UK's leading maintenance and asset management show, which takes place at Birmingham's NEC from 21-23 March. Now under the new ownership of Western Business Exhibitions, the Maintee show will be

"More connectivity provides companies with a far better knowledge of the condition of assets"

01 Increased digitisation is set to transform the ways that products are made and serviced in an industrial environment



accompanied by a wide-ranging educational programme, featuring global perspectives on topics such as predictive maintenance and how to implement connected technologies across factories and products.

"We felt it was important to increase the educational aspect of Maintec to reflect the rapid pace of technological change in the industrial sector," said Tim Else, event director. "The IoT is set to revolutionise the way that modern maintenance engineers go about their daily tasks and it's important that this trend features prominently at the show.

"Already we are seeing manufacturing companies using sensors to collect and analyse data at every point of production, meaning they can predict failures before they occur. IoT is an enabler of conditionbased modelling, and will unleash the true potential of predictive maintenance regimes. Furthermore, by fitting sensors to equipment out in the field, manufacturers also have a better idea of how their products perform in real-world operating environments. All these topics will be discussed at Maintec, which will make for a stimulating and forward-looking event."

The show is being supported by the publication of new research that addresses how IoT is set to change the way that maintenance engineers go about their roles. The research is presented in the form of a white paper: The Future of Maintenance Engineering: How the Industrial Internet of Things Will Deliver Smarter Factories with Reduced Downtime and Lower Repair Costs.

Written by industry analyst Lee Hibbert, the white paper outlines the emergence of IoT infrastructure and the impact that it is having on the role of the maintenance professional.

"The white paper argues that the move towards predictive methodologies, enabled by IoT, will mean that maintenance roles will become less about how quickly staff can fix assets, and much more about preventing equipment from failing in the first place," said Hibbert.

"The document also focuses on how IoT will transform the way that equipment is monitored and repaired out in the field. For maintenance professionals, the increased connectivity will prompt the use of new technologies such as augmented reality and wearable devices, changing the way they perform their daily roles. For instance, instruction manuals will increasingly be replaced with line-of-sight headsets that overlay technical data onto machines undergoing repair, in real time." The white paper gives several >>

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>> examples of forward-thinking companies that are employing IoT technologies to improve the way they service products. Aero-engine giant Rolls-Royce, for example, has long-since embedded its aircraft engines with sensors so that performance data can be collected and transmitted in flight. If anomalies are detected, maintenance teams and spare parts can be mobilised for immediate action, once the plane has landed. This approach has enabled Rolls-Royce to expand from an being an aircraft engine maker to become service-based provider, allowing it to charge customers for 'power by the hour'.

But Rolls-Royce has now taken its IoT capability one step further, moving beyond current levels of proactive monitoring of engine health and in-flight performance. In a new arrangement with Microsoft, an expanded network of sensors will be combined with digital technologies such as advanced analytics and connectivity to enable Rolls-Royce to collect and aggregate data from disparate, geographically distributed sources, merging information on engine health, air-traffic control, route restrictions and fuel usage to detect anomalies and trends. This additional insight will help airlines to fly routes more efficiently, and therefore reduce delays. It's a transformative step in IoT capability that will allow the aviation sector to integrate much broader quantities of operational data.

The white paper also highlights how the ThyssenKrupp industrial group has used IoT technologies to transform the way it does business. ThyssenKrupp was an early adopter of predictive maintenance, installing its lifts with a suite of sensors that can collect and send real-time data to the cloud, with the information provided used to calculate the remaining lifetime of key components and systems, flagging issues before they occur. Valuable machine data, such as door movements, trips, power-ups, car calls and error codes, is collected from lifts located across the world, providing precise and predictive diagnostics to technical teams in real time, indicating where intervention is required.

A recent addition to this capability has seen ThyssenKrupp work with Microsoft to equip its on-site technicians with mixed-reality HoloLens headsets, that will







provide them with visual indicators in their field of view to assist with repairs. ThyssenKrupp says that its data-driven approach to maintenance has cut lift downtime by up to 50 per cent, and that the introduction of the mixedreality headsets has the potential to reduce the average length of its maintenance teams' call-out times to a quarter of current levels.

These sorts of technologies will be discussed in full at Maintec, which will feature two content streams, amounting to more than 15 hours of free conferences and seminars with more than 30 industry figures, taking place across three days. Confirmed speakers include Steve Brambley, a director at Gambica, the trade association for instrumentation, control, automation and laboratory technology in the UK, who will speak about smart maintenance, focusing on how the industrial base can get involved with IoT demonstration efforts. Prof Rajkumar Roy, director of the Through-life Engineering Services Centre, Operations Excellence Institute at Cranfield University, will speak on how digital technologies will underpin the concept of continuous maintenance, focusing on the foundations and technologies required to offer such service.

Meanwhile, Cyril Deschanel, head of IoT in northern Europe for

02/03/04 In addition to conference activities, the exhibition halls at Maintec also promise to be packed full of clever companies showcasing interesting technology Vodafone, will discuss the role of IoT-enabled technologies in supporting reliable preventative maintenance programmes; while Chris Mitchell, principal consultant at US-software giant PTC will look at how augmented reality and wearable technology will change the way that factory equipment is maintained.

In addition to the conference activities, the exhibition halls at Maintec also promise to be packed full of clever companies showcasing interesting technology. Maintec 2017 is expected to feature more than 100 exhibitors, covering a wide range of sectors, including electric motors, pumps, lubricants, hydraulic equipment, vibration analysis software and safety products. There will also be interactive demonstration areas, where visitors can view machinery and safety equipment in operation.

The show is expected to attract more than 5,000 delegates from leading companies. "We're expecting it to be a really busy event," said Tim Else. "Maintec is strategically located with three complementary exhibitions – The Health and Safety Event, The Fire Safety event, and Facilities Management – so visitors can really make the most of their time away from their day jobs. Overall, there will be more than 400 exhibitors, with no fewer than eight focused educational theatres."

The Maintec show is supported by several high-profile organisations, including the Institute for Automotive & Manufacturing Advanced Practice; the Association of Electrical and Mechanical Trades; the Society of Diagnostic Engineers; and the British Compressed Air Society. "Maintec really is a chance for the entire maintenance and asset management community to come together in one place," added Else.®

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Climate Change Act, which

government is ramping up

efforts to make sure these

goals are met, with wind energy

requires emissions cuts of 80 per cent by 2050. Now, the

As the UK's wind sector matures there are increasing opportunities for maintenance engineers. Evelyn Adams reports

at the heart of its plans. According to Renewable UK, Britain could power itself several times over using wind. And it's on track to make significant inroads into the country's renewable goals. In just 10 years, wind energy's contribution to UK electricity needs has grown from less than one per cent to 10 per cent. Today, it provides more renewable electricity than all other sources combined. As a result, the UK's wind sector is enjoying record levels of employment.

"We don't have figures on how this is set to grow," said Adam Wentworth, a spokesperson for Renewable UK. "However, it's clear that demand will be in line with strong growth in wind-farm projects in recent years. These wind farms have a lifespan of 25 years and technicians work on them throughout this period. For example, Scottish Power Renewables is developing its East Anglia One offshore wind farm; a £2.5bn investment requiring an estimated 3,000 skilled employees."

East Anglia One, which is located off the Suffolk coast, consists of up to 102 Siemens offshore wind turbines and foundations, each rated at 7MW providing a generating capacity of up to 714MW. Not only are these being constructed, but they will also need to be maintained over the coming years, creating hundreds more jobs in the

"East Anglia One offshore wind farm will require an estimated 3,000 skilled employees"

Adam Wentworth, Renewable UK



process. Onshore construction works of East Anglia One are scheduled to start this year, followed by the offshore construction works in 2018. It will be fully operational by 2020.

While there are plenty of opportunities for maintenance engineers in the sector, the work can be challenging, Wentworth warned. "Onshore and offshore wind farms require working at height in isolated locations," he said. "Offshore wind farms also have to be maintained while factoring in sea conditions. The weather also plays a role in maintenance challenges. Skilled engineers are in demand across the wind industry. For offshore wind, experience working in other parts of the offshore energy sector, such as oil and gas, is highly sought after, with aptitude, professionalism and transferable skills all highly valued."

Andrew Jamieson, chief executive of the Offshore Renewable Energy Catapult, said: "As the industry evolves it is going to understand the challenges it faces much better. If we look at power generation from gas, coal and nuclear, those are industries that have spent millions of man hours solving the issues they face and making things better, more efficient and extending the life of their assets, and that's the next stage for onshore wind." As an emerging industry, there are plenty of opportunities for maintenance engineers to make their mark, and be part of a change that will make a lasting impact on the country.

Jamieson said the costs of energy from offshore wind have fallen in recent years and there is a massive opportunity to export energy across Europe. "That growth is driving opportunity in many areas, and we now have the chance to develop the companies, the workforce, the skills and expertise that will do for the UK, and for Scotland, what the oil and gas industries have done so successfully for the past half-century." Maintenance engineers with the right skills are likely to have long-term roles that will evolve as the technology progresses.

Alan Fitzpatrick, IPlantE vice-chair at the Society of Operations Engineers (SOE), said maintenance engineers will be faced with the challenge of changing gearboxes, blades and nacelles off shore, requiring items such as jack-up barges and having to face loss of items into the sea. Often engineers will be working in some of the harshest environments in the industry, which means the sector is not for the faint-hearted.

"There are a growing number of offshore wind farms coming out of their warranty phase in the UK," said Brian Pridmore, head of operations



execution, DONG Energy Wind Power. "This means the assets are transitioning from being 'new' into a core operational phase. With this transition comes different challenges: optimisation of servicing, heavy replacement parts (gearboxes, transformers), condition monitoring, preventative maintenance and monitoring asset integrity, all while keeping the machines running in what can be a very hostile offshore environment.

"A myriad of engineering skills is required, from non-destructive testing for inspections to high voltage and cabling work," said Pridmore. "We need engineers of all kinds, including metallurgists, materials engineers, mechanical engineers, civil engineers, electronic and electrical engineers. The parallels from many engineering backgrounds are clear. There is a large crossover with conventional power generation systems and traditional offshore industry such as oil and gas. There are also transferable skills from aerospace, defence, marine engineering and even Formula One.

"DONG Energy, for instance, has eight operational offshore wind farms in the UK and another four in construction, including Burbo Bank Extension that will become operational this year. With a growing operational portfolio across the entire UK there is a huge demand for engineers and skilled technical professionals within the operations and maintenance of offshore wind farms.

"If you have a passion for working in renewables, in the most cuttingedge company that is helping to grow the offshore wind industry, then research DONG Energy and the industry, keep an eye on the recruitment pages and try to make use of any industry forums or conventions to become as familiar as possible with the industry and its demands." (i)



"There is now huge demand for engineers and skilled technical professionals in the operation of wind farms"

Brian Pridmore, DONG Energy

01/02 Engineers on site at Walney offshore wind farm *Image: DONG Energy*

03 Larger turbines can be accessed by helicopter *Image: Siemens*

04 Maintenance engineers at the London Array





Rheinmetall Defence is one of the world's leading producers of defence systems and equipment for ground, air and naval forces. Rheinmetall Defence operates across three divisions; Weapons & Munitions, Electronic Solutions and Vehicle Systems setting global standards for excellence in our field.

The Vehicle Systems Division consists of two legal entities; Rheinmetall MAN Military Vehicles which is jointly owned by Rheinmetall AG and MAN Truck & Bus AG and is a leading global provider of military logistical and wheeled tactical vehicle systems and Rheinmetall Land Systems (RLS) which is responsible for tracked tactical vehicles and turret systems.

Following recent contract success in the United Kingdom, Rheinmetall is investing in a UK team to support both these, and other strategic business opportunities. Rheinmetall Defence UK (RD-UK) is seeking interest in a range of exciting engineering opportunities based in Bristol:

Systems Engineers – design, development, qualification, manufacture and in-service support aspects of the whole vehicle design. Providing the technical expertise in both project delivery and bid capture work spheres.

STA Engineer – sighting system performance and integration within a complex platform architecture; system-level analysis through to specification of sub-system requirements and managing sub-contract requirements flow down.

Protection Engineer – disciplines of system survivability spanning physical protection, active protection and signature management; assess threat capability and input into sub-system and vehicle level trials and reporting.

Configuration Manager – create and maintain configuration baselines for developmental systems; develop the configuration management plans to meet requirements and develop deliverables; implement disciplined configuration and data management processes.

Verification Engineering Manager – generation of trials specifications; defining, fitting and operating instrumentation on vehicle trials; reliability testing and reviews and safety assessments.

Lethality Engineering Manager – provide lethality engineering planning, testing and evaluation of hardware and software in support of infrastructure development; conduct testing, evaluation and analysis and make recommendations.

Human Factors Engineering Manager – delivering all requirements associated with human centred design within armoured vehicles; conducting all relevant assessments and system level analysis, trades and balances to determine optimum architectural design.

RD-UK are seeking engineers who are highly self motivated and will bring a depth and breadth of experience that will further compliment the team and add to the future success of the business. Successful candidates will benefit from an attractive package and an opportunity to shape the future of UK military platforms.

To be eligible to apply you must hold relevant qualifications and can obtain a UK Government security clearance. To find out more about these and other opportunities with RD-UK or to apply with your CV and covering letter please contact: hr@rheinmetall-uk.com.



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Applications include: electromechanical devices; non-destructive testing (NDT); power electronics; induction heating; sensors; and industrial transformers.



Feb1919

The First World War saw armoured trains patrolling the coast to meet any threat from the German Navy

mmediately following both world wars, *The Engineer* featured articles about the machines that had helped wage war and to protect the home front. In 1919, we find a description of the fearsome armoured trains commissioned to help defend the coast.

There were two identical trains, according to the article: one for the East Anglian coast; and one for the east coast of Scotland. They were a group effort,

several train companies pitching in to provide component parts. For both trains, the engines, positioned in the middle of the train, were provided by Great Northern Railways, and were 0-6-2-type tank locomotives of the kind used on what is now the District Line of the London Underground. All the parts above the frame were protected with armour plating and the cab windows had metal sliding shutters.

The idea behind the trains was that, in the event of an invasion, they would speed to the invasion site and deploy an infantry force, backed up with artillery from two gun carriages at either end of the train, which would slow down the invaders until further support arrived.

The trains carried troops, and the infantry vans were provided by the Great Western Railway, converted from 40-ton coal wagons, with half-inchthick armour on the sides and three-eighths-of-aninch thick on the roof. The enlisted men had an open carriage, built with a coal bunker under the floor and equipped with drinking-water tanks and a stove, while officers had the luxury of partitioned quarters. Both wagons had rifle loops along both sides.

The truly imposing part of each train was the gun wagons, positioned at either end of the train. Supplied by the Caledonian Railway company, each wagon had three compartments: a Maxim gun compartment at the end nearest to the engine; an ammunition compartment in the centre; and the main gun platform positioned at the end of the train. The guns themselves were the only parts not supplied by the railways; the main gun, a 12lb rapid firer, was supplied with 100 shells stored in pigeonholes, and was mounted between the carriage bogie wheels to distribute its weight and ensure that the recoil force did not derail the carriage. At the other end, the Maxim gun had 3,000 rounds on board, and a tank for cooling water to keep it in operation. Each gun carriage also included a small office for the officer commanding the train.

One peculiarity of these armoured trains was that they did not have to be operated from the footplate, like other steam trains of period. With the engine in the middle of the train, the driver's view of signals and oncoming traffic would have been completely blocked. An intermediate valve alongside the train's smokebox, with a link and lever actuated by a vacuum cylinder on the engine footplate, allowed the driver to stand at the end of the train, while communicating with the fireman stoking the engine on the footplate via a telephone.

Neither train saw action, but did provide reassurance on the coast. Both were broken up in 1919. **SN** (e)

"In an invasion, they would speed to the invasion site and deploy infantry, backed up with the train's guns" *The Engineer*

01/02/03 There were two identical armoured trains in service during the First World War: one for the East Anglian coast and one for the east coast of Scotland









GUN TRUCK LOOKING TOWARDS GUN

Word oftheissue

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

For some the epitome of motive power is the steam engine. It is noisy, an ecologist's nightmare, inefficient, expensive to run and, most importantly, it is alive. The heart of the steam engine is the boiler, an agent noun from the verb to boil. As boiling will have been used for cooking for millennia, it is not surprising to find derivations of this word are common to many languages across Europe, the Middle East and the Indian subcontinent. In its modern sense the name is fairly recent, coming to English from Old French bolir used to mean 'boil, bubble' and also 'ferment, gush'. Further back it is found in Latin bullire with the same meaning. Interestingly the homonym 'boil', referring to the skin infection, is used much earlier and shares a common origin in Proto-Indo-European beu meaning 'to swell' that is appropriate in both cases. This is also the basis for words such as 'boast', 'bole' and 'bull'.

Bigpicture



The world's largest jack-up vessel has had its mooring system upgraded by the Rotterdam Offshore Group (ROG). *Seajacks Scylla* underwent the upgrade at ROG's Waalhaven terminal in Rotterdam harbour after completing her first assignment on phase one of the 402MW Veja Mate offshore wind-farm project.



Prizecrossword

When completed rearrange the highlighted squares to spell out a mechanical device for moving a system. The first correct answer received will win a £20 Amazon voucher. Email your answer to jon.excell@centaur.co.uk

Across

- 1 Solution to mathematical problem (6)
- 4 Rules of formal behaviour (8)
- 10 Strictly adhering to convention (9)11 Subject of conversation (5)
- 12 Glowing coal (5)
- 13 Regular income from capital investment (9)
- 14 Protective garment for the torso (5,9)
- 18 A bother to the normal population (6,8)
- 20 Official trip to a workplace (4,5)
- 22 To place smaller picture inside larger one (5)
- 24 In a spoken voice (5)
- $25 \ \ \mbox{Compound not having a carbon basis (9)}$
- 26 Force from a position (8)
- 27 Open up (6)

Down

- In the open air (8)
 Wash with a brush (5)
- 3 Having wheels of the same diameter (9)
- 5 Activity of building something again (14)
- 6 Member of a Bantu-speaking people (5)
- 7 Sign of the zodiac (9)
- 8 Large, greedy insect (6)
- 9 Series of operations in computer information (4,10)
- 15 Mathematical statements (9)
- 16 Exchanging for money (7,2)
- 17 Upright in position (8)
- 19 Land surrounded by water (6)21 TV recording device (5)
- 23 Become superficially burned (5)

Last issue's highlighted solution was Austenite. Winner: Roland Smith

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