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# Change in direction

s we've often remarked, few areas of industry have experienced more profound technological change in recent years than the automotive sector: where electrification, connectivity and autonomy (concepts considered fringe just a few years ago) are now centre-stage of most OEMs' plans for the future.

A visit to any of the major motor shows underlines the scale of this change and the degree to which it is transforming the way the industry thinks about the products it produces. Walk the aisles of Frankfurt, Paris or Geneva and all the talk these days is about "mobility solutions" rather than cars.

Radical as it all seems, however, we're only beginning to scratch the

surface of what this golden age of automotive innovation might mean for the sector in the longer term. And many think that the technologies currently reshaping the motor car could fundamentally change the business models that have underpinned the industry since its earliest days - replacing the concept of vehicle ownership with the kind of servicebased approach more commonly associated with mobile phone usage.

In this issue's cover story (page 22) we take a look at this phenomenon in action; explore how it might transform our relationship with cars; and - critically - look at what its engineering implications might be. As Riversimple's Hugo Spowers, the brains behind the trailblazing hydrogen-powered Rasa, tells us, "mobility as a service" promises to fundamentally alter a manufacturer's relationship with the vehicles it makes: shifting the money-making

"Technologies reshaping the motor car could fundamentally alter business models "

opportunities away from obsolescence and high running costs and towards efficiency and longevity. It's a trend that's only likely to accelerate the already dizzying pace of innovation in the sector.

But before we get too carried away, it's perhaps worth flagging up this issue's other automotive feature (page 27) which looks at the development of a fascinating digital valve train technology that could breathe new life into the internal combustion engine. It's a timely reminder that amidst the irresistible forces of technological change that swirl around the automotive industry, there's still room for improvement in some of its most fundamental areas of technology.

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#### AEROSPACE

# Improving space weather warnings

UK-led mission will use spacecraft to detect coronal mass ejections Helen KNIGHT REPORTS



n early warning system for damaging space weather phenomena could be developed,

thanks to a UK-led mission for the European Space Agency (ESA).

Space weather occurs when enhanced solar activity disturbs Earth's magnetic field and atmosphere.

As well as emitting a continuous stream of magnetised plasma, known as solar wind, the sun also occasionally expels billions of tonnes of matter, threaded with magnetic fields. This matter expands outwards through space, in what are known as coronal mass ejections (CMEs).

If these huge clouds of matter pass over Earth, they can threaten satellites and aircraft, and disrupt GPS navigation systems, power grids and data and communication networks. In 1989, for example, the entire province of Quebec in Canada suffered a power blackout for nine hours as a result of a solar storm. Similarly, a 2003 space weather event caused a blackout in Sweden, while an estimated 10 per cent of the entire satellite fleet suffered some sort of anomaly or malfunction.

A recent ESA study estimated the socio-economic cost of a single, extreme space weather event could be as much as €15bn (£13.4bn).

Now a new ESA concept mission is hoping to provide accurate advanced warnings of such events. This would give power grid operators more time to take measures to protect their networks, for example, according to Emanuele Monchieri, project manager for the solar sentinel mission at Airbus UK, which is leading the development of the overall mission, including the spacecraft itself.

"We hope to increase the warning window, in order that we can

intervene early on, so we have the time to put in place mitigation measures on the ground and in the air," he said.

The spacecraft will be placed at a fixed point, away from the direct line between the sun and Earth, known as the 5th Lagrange point (L5).

CMEs will typically travel at between 300-3,000 km/s, meaning there can be a very short window between detecting the event and it reaching Earth.

By placing the spacecraft at L5, which is at around a 60 degree angle from the sun-Earth line, it should allow operators to spot signs of a CME earlier, said Monchieri.

This position should also make it easier to monitor the direction of the CME. "It also allows us to estimate the speed of the coronal mass ejection early on, we can follow it from when it detaches from the sun until it arrives at Earth," said Monchieri.

The mission also involves the Science and Technology Facilities Council's (STFC) RAL Space department, which will be leading the development of instruments to observe the sun and the heliosphere. Meanwhile UCL Mullard Space Science Laboratory will lead the development of instruments to measure the solar wind.

"We will have a magnetograph and an ultraviolet imager, which will allow us to monitor the active regions on the sun - the sunspots - to investigate the magnetic field and potentially enable us to predict coronal mass ejection formation," said Monchieri.

An atmospheric imager will monitor the Earth-sun line, allowing the spacecraft to detect the speed and direction of coronal mass ejections more precisely.

"We will also have an instrument that will allow us to understand the intensity of the coronal mass ejection, how powerful it is," he said.

A competing spacecraft platform will be developed by OHB in Germany. At the end of the studies, in around 18 months' time, ESA will select a final design for the spacecraft and instruments.

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#### ELECTRONICS

# Low-cost way to tackle allergens

Liverpool University teams up with Dyson to produce device for the home HELEN KNIGHT REPORTS

round 12 million people in Britain suffer from allergies, which are believed to cost the UK around £7bn in

lost productivity each year.

Now a low-cost consumer device designed to remove allergens from the home is being developed in an EPSRC-funded project by researchers at Liverpool University, working with Dyson.

The device, based on cold atmospheric pressure plasma (CAP), is designed to reduce the concentration of airborne allergenic agents from within an indoor environment. These allergens include house dust mites, pollen, household chemicals such as cleaning products, and fungal spores, according to Dr James Walsh at Liverpool University, the project's leader.

Cold plasma is a form of ionised gas in which energetic electrons and ions coexist alongside a wide variety of highly reactive chemical compounds.



When cold plasma comes into contact with contamination in the air, such as an allergy-causing fungus or chemical, it has a powerful decontamination effect.

"We apply electricity to air, which breaks the air apart into its constituent parts; electrons, atoms, and some reactive molecules," said Walsh. "When that interacts with a fungus, say, it breaks it apart."

While most people associate plasmas with heat, the plasmas developed by the device will be generated at room pressure, and low temperatures, Walsh said.

"We will be generating the cold plasma in air, so we are developing a device that actually uses the plasma to suck the air from the room through the device, and in the process of doing so cleaning it," he said.

Unlike conventional devices, the plasma technology does not require the use of a physical filter, which can become blocked or need replacing. What's more, it does not need a pump or fan to draw air into the device and push it through, meaning it consumes much less energy.

"There is no real resistance, the air is just passing through a region of a high electric field, where it is getting bombarded by chemical species," said Walsh.

The technology only requires air and electricity to operate, typically using ten times less power than a household lightbulb. This should make it suitable for continuous use in the home.

To develop the device, the researchers will first construct a pulsed air plasma source that creates a plasma rich in highly reactive chemical compounds.

The researchers will take diagnostic measurements of common household allergens passing through the plasma device, to understand how they break down, said Walsh. "We don't yet know what happens when a complex allergen passes through a complex plasma," he said.

ROBOTICS

#### Software for robots to enter plants

# 3D sensors will help in dismantling process

Software to allow robots to enter an unfamiliar nuclear site and dismantle radioactive equipment is being developed in Britain.

Cumbria-based Createc, which develops imaging and sensing technology, is leading a £1.5m project to develop the software, funded by the Nuclear Decommissioning Authority, Innovate UK and the Department for Business, Energy and Industrial Strategy, in partnership with Sellafield.

The nuclear industry has traditionally used large, purposebuilt robotic machines to carry out decommissioning work, said Matt Mellor, a director at Createc.

Instead, the team believes the future of nuclear decommissioning lies in the use of smaller, cheaper and re-usable human-sized robots that can be deployed in unmapped plants. The robots would then explore the plant, using 3D sensors and navigation software, explained Mellor.

"We want the robots to perceive

what is going on around them, and then feed that perception directly to a human operator, using virtual reality," he said.

Information from the 3D sensors will be fused together using an algorithm known as SLAM, he said. "This is a computer perception process that looks at the data, understands how it all fits together into one 3D image, and simultaneously works out the location of all of the sensors," he said.

In this way, the algorithm can work out not only where the robot is in its environment, but also its pose. This information can be used to allow the human operator to control the robot's decommissioning work using virtual reality, said Mellor. ■

#### **Newsinbrief**

#### Train seat innovation

42 Technology has been awarded almost £350K by Innovate UK to help further commercialise its Adaptable Carriage train passenger seat mounting system. The funding will enable the company to install its technology into a train carriage for the first time. Adaptable Carriage will allow seats and tables on passenger trains to be automatically folded and stowed to create space for freight.

#### Vehicle-to-grid

Almost £30m is being made available by government to support the research, design and development of 21 vehicle-togrid (V2G) technologies in Britain. This includes EDF Energy's V2GO scheme, which will demonstrate how energy stored in electric vehicle batteries could be used in the electricity grid during peak hours, before being recharged during off-peak hours in time for their drivers to use them.

#### Roc<u>ket man</u>

Elon Musk's Falcon Heavy was successfully launched from the Kennedy Space Centre in Florida. Composed of three Falcon 9 nine-engine cores, the spacecraft is able to lift into orbit nearly 64 metric tons (141,000 lb). This is more than twice the payload of the next most powerful rocket.

#### **Bioprinting breakthrough**

Researchers have developed a bioprinting technique that combines molecular self-assembly with additive manufacturing; an advance with potential benefits for tissue engineering and drug testing. The project is led by Queen Mary University of London.

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#### DEFENCE

# Flexible firepower moves closer

Tests on payload bays that will adapt to carry different weapons systems HELEN KNIGHT REPORTS



lexible combat aircraft that can carry different weapons systems or stores depending on the task required of them are a step closer.

following successful ground-based trials at BAE Systems.

One way to make future combat aircraft more affordable is to provide defence forces with more flexibility, in how they use them. The payload bay is one way in which this greater flexibility can be achieved, according to Phil Astley-Jones, technical lead on the flexible payload bay project at BAE Systems. "It provides the ability to simply change the weapons systems they want to carry, or to change the fundamental role they want that aircraft to perform," said Astley-Jones.

To ensure aircraft are better able

to survive combat, they will also need to be capable of carrying weapons internally. However, releasing a weapon or store from an aircraft bay at high-subsonic and supersonic speeds carries risk. The harsh aero-acoustic noise and vibration within the bay risks damaging either the aircraft or its store, while the need to rapidly open and close the bay doors increases the complexity.

To better understand this harsh environment, the company held ground trials to test the release of a full-sized store from an aircraft payload bay, using a specially built rig. "This was achieved by placing the bay test article behind the exit flow from one of our wind tunnels, and using a specific tunnel exit nozzle design to provide an airflow representative of the high-subsonic bay operational environment," said Astley-Jones.

The trial, which also involved MBDA UK and Harris, allowed the team to capture data on the release using instruments and high-speed cameras. The test culminated in the high-subsonic release of a store from the bay, and confirmed the team's expectations about the noise levels and resilience of the structure.

One area of the project that proved particularly challenging was in developing a system to safely capture the released store without damaging it, said Astley-Jones. "It was ejected at about five and a half metres a second, less than two metres above a concrete base," he said. The successful trial will provide a route to testing bay designs at full scale, he added. ■

#### DECOMMISSIONING

# Radioactive task for robots

£1.5m for technology to decommission JASON FORD REPORTS



Wood is leading a project that will integrate multiple technologies onto a single robotic platform to make nuclear decommissioning safer, faster and cheaper.

The company has secured approximately £1.5m funding from the Department for Business, Energy and Industrial Strategy, the Nuclear Decommissioning Authority and Innovate UK after winning a competition to find new ideas.

Wood and partners will combine new data and control systems with robotics to design a demonstrator system for cleaning and dismantling highly radioactive rooms at Sellafield in Cumbria.

The technologies include novel material-handling solutions to reduce the risks of working at height, mixed reality headsets, a multifingered gripper allowing robots to grasp different objects, and a navigation system designed for missions to Mars that enables autonomous mapping where human access is impossible.

"Our approach considers that most decommissioning tasks are unique but they can benefit from a common toolkit from which a solution can be implemented," said Greg Willetts, vice president of Wood's nuclear business.

"Our partners have been selected on the basis that they can support better ways to bring systems together to make the best solution for the job."

Willetts added that Sellafield will provide the use case for the project but the ambition is to deploy these technologies and solutions across the wider UK and international nuclear decommissioning market.

#### ENVIRONMENT

#### Removing micropollutants Project to test metal foam technique

A chemical engineer at Bath University has been given a five-year EPSRC Fellowship to develop photocatalytic nanoporous anodic metal foams that can remove micropollutants from water.

Micropollutants – found in toxic chemicals such as drugs, hormones and pesticides – appear in waste water in low concentrations, and can eventually work their way into the food chain via the soil, potentially causing long-term harm. Most water treatment plants in Britain lack the ability to remove these chemicals, and impending legislation could necessitate significant investment from the industry.

A team led by Davide Mattia, professor of chemical engineering at Bath University's Centre for Advanced Separations Engineering (CASE) and Water Innovation & Research Centre, is working on a solution claimed to be environmentally sound and cost-effective. A highly porous photocatalytic metal foam captures the micropollutants, which are broken down into harmless organic compounds by sunlight. Unlike other photocatalytic methods, the nature of the foam prevents leaching of nanoparticulate material, keeping toxic compounds out of the food chain. **AW** 

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#### MEDICAL

# Hospital pilot for AI analysis of foetal scans

### Instant review will mean sonographers capture the correct images Helen KNIGHT REPORTS



oetal ultrasound technology that uses artificial intelligence to review images as a patient is scanned is being piloted at a UK hospital.

The real-time analysis software, called ScanNav, is being piloted by the foetal medicine department at St George's University Hospitals NHS Trust in Tooting, London.

The Al system, developed by Cardiff-based MedaPhor Group, is designed to carry out a "peer review" of the ultrasound images during the scan.

Manually auditing ultrasound scans to ensure they conform to medical protocol is a time-consuming process, according to MedaPhor's chief technology officer, Nick Sleep.

By providing an instant review, the Al system allows sonographers to take additional images immediately if needed, he said.

"Sonographers want to make sure that they capture the right images, and they want to make sure that those images are of good quality," Sleep said. "It's actually quite a pressurised environment; they are dealing with a baby that is moving, and a mother who is probably quite worried to be having a scan."

The system should help newly qualified sonographers to ensure they take good-quality scans, as well as reassuring more experienced specialists that they have not inadvertently missed an image, he said.

The technology is initially aimed at use as part of the UK's pregnancy screening programme, for which it is capable of evaluating more than 50 different criteria to verify that the six views required by the programme are fit for purpose.

ScanNav uses machine-learning algorithms to identify and grade ultrasound images. It has been trained on more than 350,000 images to assess the same features sonographers look out for.

"We sent scans to a panel of expert sonographers, who first categorised them and then graded the images against clinical criteria," said Sleep. "We then feed those images into deep learning algorithms, which try to match the features in the image with the results we have given."

In this way the algorithms learn to make a decision on images based on information gleaned from the database of previous scans.

The technology could also be applied to ultrasound procedures outside of obstetrics, including checking liver or kidney scans, for example, or looking for signs of trauma in A&E patients, he said.



#### HOUSING

### Build more homes to suit older people, says report

#### Careful construction could save lives

A report from IMechE is calling on government to provide incentives for construction companies to build homes designed with older people in mind, a move that could ultimately reduce costs for taxpayers.

Healthy Homes: Accommodating an Ageing Population also recommends that product suppliers and manufacturers step up efforts to develop retrofit technology to allow people to live in their homes for longer.

Around 18 per cent of the UK's 65.6 million population is aged 65 and over, and 2.4 per cent aged 85 and over. Many of these older adults downsize as they become less active, which can exacerbate mobility issues and the onset of frailty, resulting in higher risk of falls or injury. According to the report, physical inactivity costs the NHS £10bn a year, with £2.5bn spent on care as a result of poor housing. Furthermore, allowing vulnerable people to remain in homes with significant hazards is costing the NHS nearly £414m per year in initial treatment costs. **JF** 

#### AEROSPACE

# Laser system awarded €1m

Aim is to make satellite communication faster



A technology spin-out from Dublin City University has received almost €1m (£890,000) from Kernel Capital to help expand its team and accelerate the company's international growth plans.

Pilot Photonics' technology is an optical comb source, a versatile laser system that enables constellations of satellites to communicate at higher speeds, an important consideration for handling large volumes of data that satellites currently gather and transmit.

The investment, made by Kernel through The Bank of Ireland Kernel Capital Funds, follows a contract from the European Space Agency through its Advanced Research in Telecommunications Systems entry programme. Company CEO Frank Smyth said the project will require the development of an RF drive source, a dedicated optical package, and a new optical comb laser source based on photonic integration. The company will also develop a housing and driver module for the comb source as well as conduct verification and initial space readiness tests.

"Once all of this is complete, the goal is to begin to examine its use for space applications including optical inter-and-intra satellite communication, fibre optic sensing for structural health monitoring on satellites, as a light source for rubidium atomic clocks, gas spectroscopy, and other applications," he said. "

Special sputtered coatings will also need to be used given the harsh environment testing that is required.■



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#### AEROSPACE

# BA leads in flight broadband race

Airline will be first to offer high-speed internet to its passengers Helen KNIGHT REPORTS



assengers on British Airways flights will be the first to begin using the new European Aviation Network (EAN), a dedicated

broadband service for aircraft developed by Deutsche Telekom, Inmarsat and Nokia.

The EAN service consists of S-band satellite-based and ground-based networks, and is designed to provide airline passengers with access to the same wireless internet speeds they are used to in the home.

Passengers will be able to use social media, share pictures and stream high-bandwidth content during their flight.

The companies recently completed the set-up of around 300 base stations across the 28 EU member states, plus Switzerland and Norway. This makes it the first Europe-wide network based on LTE technology, a high-speed wireless communications standard.

The announcement follows Inmarsat's launch of its EAN satellite in June 2017, which began operating in September. The service will offer a high-bandwidth service to customers, whether the aircraft is flying over land or water, with over 75Mbit/s connection speed to aircraft. This is because airlines using the service do not share network capacity with any nonaviation customers, Inmarsat said.

Unlike conventional wireless networks, the system needs to operate at speeds of up to 1,200km/h, heights of 10km, and with cells of up to 150km in size.

The system uses lightweight avionics, allowing even single-aisle, short-haul aircraft to be equipped with the service, according to a spokesperson for Inmarsat. "Standard terminals avionics would weigh in the region of 184kg, covering the terminals, servers, routers and cabin network," the spokesperson said. "With EAN, this total weight is 60 per cent lighter, at around 74kg."

The equipment can be installed on individual aircraft during overnight breaks. The network will be available for commercial use in the first half of this year, and the networks have already undergone trials. Its first customer, International Airlines Group (IAG), which includes British Airways, Iberia, Aer Lingus and Vueling, has already begun installing the network equipment.

Dedicated aviation networks already exist in the US, but not in Europe. A recent Inmarsat survey found that 44 per cent of European passengers would stop using an airline within the next 12 months if it didn't offer in-flight internet.



#### AUTOMOTIVE

#### Drive for speed

#### EV batteries could be charged much faster

Lithium-ion batteries, such as those in electric vehicles, can be safely charged five times faster than currently recommended, according to a new study.

Conducted by researchers at WMG (Warwick Manufacturing Group) at the University of Warwick, the work involved formulating a new precise test for measuring internal battery temperature and electrodes potential.

Using an in-situ reference electrode and optical fibre temperature sensor, the WMG team was able to measure

the potential of each electrode in an EV battery, alongside the cell's internal and external temperature. With that data, the researchers could determine how aggressively the battery could be charged while remaining within the thermal and potential safety limits of the cell. It was found that the maximum charging current that could be safely applied was 6.7 times higher than the manufacturerstated maximum.

Having established the batteries could withstand much higher demands, the team then developed a rapid-charging protocol that leads to more than a five-fold reduction in charging times without compromising safety limits. **AW** 

#### RAIL

# New centres of excellence

#### Universities team up with industry bodies JASON FORD REPORTS



The UK rail industry has launched four centres of excellence with UK universities that are expected to help shape the global future of railways. Covering rolling stock,

infrastructure, digital systems and testing, the UK Rail Research and Innovation Network (UKRRIN) has been established to give the rail industry access to purpose-built facilities and skills to support research, development and innovation for new technologies.

Southampton University will lead the Centre of Excellence in Infrastructure. Three other centres will focus on digital systems (led by Birmingham University), rolling stock (led by Huddersfield University) and Testing (led by Network Rail).

Rail minister Jo Johnson said: "New centres of excellence, bringing together experts, universities and the wider rail industry will be essential in achieving our ambition to get all diesel-only trains off the track by 2040 as well as delivering the advanced railway network that passengers deserve."

UKRRIN has been established following a £28m bid to the Higher Education Funding Council for England and is backed by a commitment from industry to invest more than £60m at these centres.

The network's key objectives include the development, delivery and deployment of new technologies, increasing UK rail productivity and performance, developing strategic relationships with the SME supply chain, rail industry and wider sector, and step-change investment in rail innovation through UK-based research and testing centres.

# Fit for the future: will the 4th industrial revolution be good or bad for our health?

t the recent XXI World Congress on Safety and Health in Singapore, Secretary General of the International Social Security Association (ISSA), Hans-Horst Konkolewsky, asked a large audience of international safety practitioners whether the 4th industrial revolution will be good or bad for worker's health and safety. Overwhelmingly the answer that came back was that yes, ultimately the changing world of work will be good for our health and wellbeing. However, there will be many challenges to navigate - and risks to understand and control - before these revolutionary changes have been completed.

What are the nature of these changes? The British Safety Council has commissioned RobertsonCooper to produce a literature review, 'Future changes to the world of work and the impact on employee health, safety and wellbeing,' into the state of research about the changing world of work and their associated risks. The review tells us that people are living - and working - for longer; that many tasks are being automated; modern communication technologies are dissolving the work/home divide; new materials like nanotechnology (including tiny airborne waste products that can damage our health) and new techniques can present new risks; and an increasing use of more 'flexible' employee contracts.

With these deep and fundamental changes to work, the risks associated with work are also changing. The spectre of automation is of course at the heart of many of these discussions. Research by IPPR says that 10 million jobs are at risk from automation in the UK. When those health and safety practitioners were asked the question about the future risks of work, the health advantages of automating certain hazardous processes (for example the increasing use of automated riveting or 3D printing) - and by implication the removal of people - was uppermost in their minds. There are also health benefits to these modern, flexible ways of working where people are adding specific value to automated processes.



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However, automation may increase inequality - at least in the next 20 years and there will be many less skilled workers who will not benefit from such changes. Besides, a simple calculation of increasing automation may not fully reflect what will happen as we are already seeing countertrends of people being re-introduced into the workplace with recognition of the benefits of human labour. It is far more likely that people and intelligent machines will increasingly become 'colleagues' in the future. A colleague who can work without breaks, who is always 'on,' who isn't going to share much 'social' information, is a very different colleague; a relationship that could easily create stress and undermine wellbeing. We also know that people at work derive important health benefits from the social nature of work and this will be an issue to address in the future. Evidence also tells us that the health benefits of 'good' work, whether we define this in



Research by IPPR says that 10 million jobs are at risk from automation in the UK terms of good employment practices, reward and recognition or fulfilling jobs, can be either enhanced or undermined by disruptive technologies.

In its 60-year history, the British Safety Council has always made sure it has the most up to date information on the risks that people experience at, or bring to, work. To argue for change, evidence must be at the heart of everything we do and this report by Professor Cary Cooper's team gives us a roadmap to plot a series of discussions, seminars, events and campaigns. Seminars hosted by the British Safety Council at The Health & Safety Event (NEC, Birmingham, 10-12 April 2018) will be one opportunity to steer us towards a fitter, healthier and happier future.

Free registration for The Health & Safety Event is now open, visit www.healthandsafetyevents.co.uk

#### MEASUREMENT

# Optical clock for better mapping

Transportable device may be used to measure rising sea levels HELEN KNIGHT REPORTS



accurately mapping Earth's surface. A European team, including researchers from the UK's National Physical Laboratory (NPL), carried out the experiment using one of the world's only transportable optical

atomic clocks. According to Einstein's Theory of Relativity, clocks closer to massive bodies run slower, meaning a clock at the bottom of a mountain will run more slowly than one at the top.

Optical clocks are sensitive to these changes, accurately measuring height differences as small as 1cm across Earth's surface.

Unlike satellite-based measurements, which average the gravity potential over large distances, optical clocks can make measurements at specific locations. And with a transportable clock these measurements can be further pinpointed, according to Helen Margolis, a fellow in optical frequency standards and metrology at NPL. In this way the technique could be used to monitor changes to Earth's gravity potential caused by climate change, for example.

In an experiment described in Nature Physics, the team transported the optical clock to a laboratory 1,700m below a mountain, in the Fréjus road tunnel between France and Italy. "We took the clock to this particular lab under the Alps because the area is subject to long-term uplift, which means that the gravity potential is slowly changing over time, giving us a realistic test bed," said Margolis. "But you could also imagine placing them in locations where you could monitor changing sea levels that might result from climate change."

Optical clocks have been restricted to laboratories, but researchers at the Physikalisch-Technische Bundesanstalt (PTB), Germany, recently developed a transportable strontium optical lattice clock. They took it to the South of France, where it was connected by optical fibre link to another optical clock at the Istituto Nazionale di Ricerca Metrologica (INRIM), 90km away in Turin, at a height distance of around 1,000m. The team then measured the gravity potential difference between the clocks.

Since the portable clock and the laser used to transmit over the fibre operate at different frequencies, NPL researchers provided a frequency comb to relate these different frequencies, allowing the devices to be connected, said Margolis.



#### MEDICAL

#### Faster haemorrhage control New cotton-based solution from Singapore

Aerogels made from waste cotton-based fabric can be used to control haemorrhaging, claim researchers from the National University of Singapore (NUS) Faculty of Engineering.

Current haemorrhage control devices comprise a syringe filled with small capsules of cellulose-based sponge, coated with chitosan, a natural agent derived from crustacean shells that promotes blood clotting. The syringe is inserted into the wound to release the capsule, which expands and applies pressure on the wound to stop the blood flow. According to NUS, the expansion and absorption rates of cellulose-based sponges are still relatively slow.

To address these limitations, NUS researchers developed highly compressible hybrid cotton aerogel pellets that are said to be more effective than the cellulose-based sponges for treatment of deep haemorrhagic wounds.

NUS further claimed that the pellets – comprising cotton and cellulose aerogels coated with chitosan – are simple and cost-effective to produce, and they can be easily integrated into a clinical syringe to be used as a haemorrhage control device. **JF** 

#### ROBOTICS

# Magnetic microbots

#### New approach for guided drug delivery STUART NATHAN REPORTS

Engineers at Purdue University have devised a highly unusual mode of locomotion for constructions measuring around 400µm by 800µm, which can act as guided drugdelivering medical microbots.

Magnetic fields have been seen as an attractive method of guiding and propelling microbots, but very strong fields have, until now, always been necessary.

The Purdue team, led by David Cappelleri, director of the Multiscale Robotics and Automation Lab in the university's School of Mechanical Engineering, devised its new approach by building magnetism into the robot itself.

In a paper in *Micromachines*, the team details microbot construction from polymer materials in a flat, dumbbell shape with magnetic ends and non-magnetic midsection.

When influenced by a constantly rotating magnetic field, the microbots – dubbed µTUMs – tumble end-over-end at speeds of around 60 body lengths per second (48mm/s) in dry environments and 17 body lengths per second (13.6mm/s) in wet environments that mimic conditions inside the body.

As well as reducing the field strength needed to move the robot, the tumbling motion gives it a surer footing on surfaces. At very small scales, electrostatic interaction between particles can cause microbots to get stuck.

"Unlike the µTUM, other microscale robots use a rocking motion under an alternating magnetic field, where contact between the robot and the surface is continually lost and regained," said Chenghao Bi, lead author of the paper. "Though the continuously rotating field used for the µTUM is harder to implement than an alternating field, the trade-off is that the tumbling robot always has a point in contact with the ground, provided that there are no sharp drop-offs or cliffs in its path." ■

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viewpoint | philip law

# We need to recognise the value of plastic

Design-led, science-based approaches will ultimately mean we can eradicate harmful waste and benefit fully from this remarkable material

lastic is not designed to end up in the marine environment – yet around the world plastic waste is leaking into our oceans. Tackling this issue requires a widespread response at international, governmental and local levels. As

more than 80 per cent of marine litter comes from a small number of Asian countries, these areas are highly significant. However, every country – and arguably every citizen – has a role to play as we rethink our relationship with this remarkable material.

The modern world is made possible by plastic. It saves lives in hospitals in medical devices, helps supply our drinking water via durable pipes, is essential for digital devices to function and helps preserve our food. Plastic packaging, often in the spotlight for negative reasons, is lightweight and cheap to produce. It can be solid or flexible, transparent or opaque, chemical-resistant, heat-tolerant, and safe for food contact. According to a 2016 Trucost report, environmental costs increase four times without plastic packaging – with production, shipping and end-use environmental impacts all rising.

Biodegradable plastics have often been mooted as a potential solution. However, what isn't generally recognised is that special conditions are often needed for the material to decompose, such as those provided by industrial composting. Additionally, biodegradable materials have been shown not to fully break down within the marine environment. Biodegradable plastics that end up in landfill also have the potential to release methane, a more potent greenhouse gas than CO2. Very importantly, biodegradable plastics can also undermine existing recycling for conventional plastics and preclude their use in numerous long-term applications. Even the very suggestion that they may be present in these recycling streams can cause specifiers to be concerned about the integrity of their products.

It is technically possible to recycle all plastics. However, economics largely determine those that are recycled at scale, showing a truly circular economy should begin with design. Designers should create packaging that can easily be recycled. But designers ultimately are steered by clients' demands, so brands and retailers also have an essential role to play. The principles of the current UK recycling infrastructure are, however, solid. Kerbside collection works. Some 99 per cent of local authorities collect plastic bottles, with the number of local authorities collecting pots, tubs and trays increasing and currently at 76 per cent. The UK is ranked second for commercial and industrial packaging recycling in the EU, and seventh for plastic packaging. Currently 22 per cent of plastic packaging reaches landfill, but the UK plastic supply chain's current aim is to reach zero by 2030.

Improvements to the system are needed but each proposal should be carefully considered. Deposit return schemes (DRS), for example, are a prima facie 'green' solution where consumers return their own bottles. Some DRS systems, such as Germany's, work well. Others, like South Australia's, do not. One complicating factor is the unknown impact on the well-established kerbside collection system in the UK, with a DRS potentially siphoning off valuable items.

The British Plastics Federation Recycling Group's strategy document of 2017 proposed introducing incentives for companies to use recycled content and for products to be designed to maximise recyclability. Extended producer responsibility (EPR) can help achieve this, with companies offsetting their producer responsibility costs through resource-efficient product design, such as specifying a certain percentage of recycled content. Critically, a reformed Packaging Waste Recovery Note system – which certifies plastic has been properly recovered or recycled – is needed that encourages the growth of UK recycling infrastructure. Littering needs to be addressed too.

There are limits to conventional recycling – multi-laminate, composite and thermoset materials, as well as contamination, all pose challenges. Chemical and pyrolysis recycling methods provide a potential answer – technologies that break down long polymeric carbon chains into medium-length chains, producing waxes and synthetic crude oil to make new plastics. Scaling these technologies up will require investment.

In developing nations without waste infrastructure, local solutions are needed. NGOs such as Waste Aid work with communities to turn plastic waste into economic opportunities.

A theme runs through this – recognising the value of plastic. The future should be one in which the consumer recognises plastic as a recyclable and valuable resource and seeks to keep it working within the economy. Society needs plastic – and it can't afford to keep throwing it away.

Philip Law is director-general of the British Plastics Federation and of the Council of International Plastics Industry Association Directors (CIPAD)

> Currently 22 per cent of plastic used in the UK reaches landfill, but the aim is zero





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# Mailbox

### **The**hottopic

#### **Funding STEM** education

Our online poll on how STEM degrees should be funded in the future sparked a heated debate

Courses that are of benefit to the country and the economy should be prioritised and subsidised at the expense of the pointless 'vanity' courses. And the number of universities should be reduced. Steve

Governments have lost the plot. In one breath they are telling us of the lack of skills in this country, yet they wish students who will be wealth creators to get into £50,000 of debt. This does not encourage the best students. University is not the best route in all cases. Apprenticeships would not cost the student anything like £9,000 a year and they would have a positive contribution throughout their training and thereafter. The politicians should encourage companies, with tax relief as one suggestion. **AB** Dutton

For too long the degree has been the only way for youngsters to get a job, with many



companies, large and small, insisting on that piece of paper before even interview. At the same time, the large number of people with degrees has actually devalued the degree itself. At last, more companies are finding that bright apprentices are at least equal value to those who choose the degree route. 20 Cent

There is discussion at the moment of paying students a living wage to study: I would applaud such a move. However, students should pay fees in inverse proportion to the usefulness or difficulty level of the course undertaken. Humanities or social courses should be charged to make them less attractive, reflecting their low value to society. Mathematical, medical and modern-language courses which provide training that is of importance to society should be low-cost with a

positive discrimination to encourage more females to follow this route. **Jack Broughton** 

If the country "needs" people with STEM skills, then it is very reasonable that "the country" (taxpayers like us) should fund a large part of the costs – the money for this coming from the future higher productivity "the country" will enjoy from having more STEM-skilled citizens. Perhaps the fees the students will have to pay, could be based, not so much on the cost of providing the course, but on the value to the country in the future of having citizens with those skill sets. intellimouse

Engineers should not take a chauvinistic approach to other specialty areas and alternative 'career' choices. All education is important and universities are there to educate. not to provide job fodder. Steve

Both of my children attended university, both leaving with good degrees. One is a veterinary surgeon and one a building surveyor - and both have large debts. When I took my degree in mechanical engineering I was lucky in that my fees were paid by the government and student grants were available. Consequently, I have quite a good grasp of two different methods of funding education. It isn't rocket science to work out that I had a much better deal than my children. What I genuinely struggle to understand is how the country could go back to the system under which I was educated. In those far-off times less than 10 per cent of the population had the opportunity to attend university. Consequently, the costs were much lower. I don't believe that any of the political parties have the answer. Edward

### Inyouropinion

#### **Electrification of UK rail**

Electrification of the whole network is obviously the best solution, but this won't be done because it's too expensive. Our little railway (the Uckfield line) has been waiting for electrification since the 1960s. I'm not expecting any change soon! Unfortunately, our politicians have very little knowledge when it comes to technology. John Thompson

Electrification was the 'obvious best solution' in the 1960s, but not anymore. Technology has moved on and stringing wires or installing third rails – good as they were – are no longer the best way forward. Alan Benn

It could be done a lot cheaper and quicker using different designs and materials for catenary supports (composites requiring zero maintenance but as robust as steel), different financing models (long-term leasing for the catenary and power supply infrastructure) and competitive powersupply contracts. This would be a whole new growth market for the power supply sector. The current UK electrification always appears to be much more complex, heavy and ugly than comparable projects in Europe and elsewhere. **Phil Mortimer** 

#### **Falcon Heavy launch**

As others have said, a fantastic achievement by the SpaceX team. Elon Musk seems to be a great engineer and it's a pity that we have nobody here in the UK with similar visionary qualities Michael Breslin

Fantastic achievement. I watched it live and it took me back to the days of the Apollo Moon landings which inspired me to become an engineer. This should help inspire the next generation. The Tesla Roadster as the payload was inspirational marketing. The real gamechanger will be BFR. Then, manned space exploration can get going again. Can't wait! Steve Bee

We witnessed history in the making! Well done Elon, we need more engineers like you. Heinz van Teeseling

Join the debate theengineer. co.uk



### Thesecretengineer

From F1 'grid girls' to Falcon Heavy – we've missed golden chances to put engineering in the spotlight, says our anonymous blogger

We have just had a few weeks of momentous happenings which, in turn, led to people getting into a terrible tizz on the interweb (both in a good and a bad way).

Of course we all know that engineers influence virtually every aspect of life, but I was left wondering why the engineering-related aspects of the various stories weren't more to the fore?

Taking them one at a time, firstly there was the great outcry at the removal of 'grid girls' from Formula One. I must admit I was rather taken aback by the sheer volume of opinions given about this as well as the depth of feeling shown – also the wildly inaccurate and downright bizarre arguments made regarding the decision and its basis.

One popular argument in particular was that young girls who talked to the 'grid girls' would be encouraged into the motorsport industry, going on to be drivers, engineers and mechanics. This struck me as being a tad disingenuous but at least worthy of consideration.

Rather than merely accepting or denying this point though, where were the female engineers who could comment directly? Here was the opportunity to show why things should be kept as they were or, on the other hand, that the current situation merely reinforces the idea that boys build and drive cars, while girls hold signs and look pretty. My feeling is that all the time there is a perceived division, it's not going to help get women into engineering. By removing the 'grid girls' you break the imbalance on the side you can and help move things to a better state.

Hot on the heels of this came the centenary of women's emancipation – admittedly, true equality in voting was to come much later but this was the 'landmark moment'. As one would expect, the discourse spread out to further conversations regarding equality now and how the roles and expectations of women in society have changed.

I noted that one person had contacted a programme (which had asked their viewers to nominate their heroines) about Beatrice Shilling, but apart from that engineers seemed sadly underrepresented in the debate. If one wants to look to the liberation of women from 'traditional' expectations within the modern world then surely the historically conspicuously 'male realm' of engineering is the place to go?

Finally there was the first successful launch of the SpaceX Falcon Heavy which shot Elon Musk's Roadster towards Mars, and unfortunately



missed. Mr Musk is a natural showman, so the amount of coverage, and comment, regarding his new rocket is unsurprising.

A lot of friends on social media provided links to the live feed of the launch and have subsequently gushed about how wonderful it all was ever since. In particular, the synchronised soft landings of the two boosters really captured the imagination with many references to Thunderbirds being given.

However, while there was much excitement and admiration, I didn't see anyone comment about the engineers and scientists behind it. Not even the slightest discussion was to be found of any of the technology that has had to be developed. It seemed to be the usual case of "this is an amazing thing that has happened just because some rich fellow thought it would be cool" – rather than, say, "a lot of very clever people behind this committed to the dream and made it happen".

Within a week or two, then, we had a perfect series of chances to get our colleagues out in front of the cameras or across the interweb. The chance to explode myths and encourage young women into our profession. The chance to engage both young and old minds in the beauty and wonder of our world. Yet still we are denied exposure, or perhaps rather we fail to rise to the challenge?

We barely even make the fringe of debates and stories where we should be claiming the centre ground.

There may be follow-up programmes where we do get our due moment in the sun but not when it's current news and vital – and that is when it's most important.

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#### view from the academy | hayaatun sillem

# Supporting Africa's young innovators

When resources are scarce, ingenuity thrives, with engineering a key route to changing the world

ngineers have an essential contribution to make to improving quality of life, including among the world's most disadvantaged communities. From ensuring access to safe drinking water and adequate sanitation to providing clean energy and reducing waste, engineers are applying their knowledge, experience and creativity to drive the development of innovative solutions that make a difference to people's lives.

The Royal Academy of Engineering is strongly committed to engaging with engineering entrepreneurs across the world to advance the development and delivery of local, scalable solutions to real-world challenges. By providing them with practical support to build their skills, profile and networks, we can help to make sure that these talented people contribute to socio-economic progress through their innovation-based businesses. In addition, connecting engineering entrepreneurs from developing and emerging markets to the UK's research, innovation and commercialisation networks helps them to enhance the impact of their work and build links with the UK engineering base.

While our international programmes have been established to build capacity in developing countries, they also deliver important benefits for the UK. International engineers trained here leave with a positive impression of the UK as an innovative and entrepreneurial country, an impact that is crucial at a time when we are seeking to reposition ourselves on the global stage. Just as importantly, the UK engineering community can learn from our international partners. The applications we receive for the Academy's international awards provide just a glimpse of the outstanding innovations being developed in traditionally resource-poor environments. Engineering requires creativity to solve challenges, and when resources are scarce, ingenuity often thrives.

This is evident in the work of people like Hindu Nabulumba from Uganda, a 2017 finalist in the Academy's Africa Prize for engineering innovation, who developed her Yaaka network to connect students, academics and trainers on a single social network. Many of the countries we work with have far more diverse engineering professions than the UK, with proportionately more women involved. Hindu's approach is practical, creating Yaaka as a solution to a problem, and sees engineering as a key route to changing the world.

Since its launch in 2014, the Africa Prize for engineering innovation, supported by The Shell Centenary Scholarship Fund and Global Challenges Research Fund, has helped 56 ambitious and talented innovators from 11 countries across sub-Saharan Africa to scale their innovations to address local challenges. Each year, a shortlist of 16 entrepreneurs receive six months of bespoke business mentoring, training, and networking opportunities, to enable them to turn their prototypes into profitable businesses with genuine economic and social impact.

One such innovation is Cardio-Pad, a custom-made tablet computer, designed by Arthur Zang from Cameroon, the 2016 winner of the Africa Prize, that enables any medical professional to conduct heart examinations quickly and without the need for expensive equipment or specialist training. Cameroon only has around 60 cardiologists for its 22 million people, meaning that access to specialist heart healthcare is almost non-existent for its citizens. Hundreds of Cardio-Pads have now been built and revenue doubled between 2016 and



2017. The device has already been sold in Cameroon, Gabon, India and Nepal, with expansion to Burkina Faso and Congo planned next. The training and mentoring was vital for Arthur, inspiring him to completely rethink his business model.

International collaboration can help entrepreneurs build the networks and relationships needed to grow successful businesses. The 2017 Africa Prize shortlist included James van der Walt from South Africa. His SolarTurtle is a mobile power station that provides instant electrification to remote and unconnected communities. Since being shortlisted the team has developed a new automated version of the power station in collaboration with the University of Liverpool. This collaboration was the result of James's participation in another Academy programme, Frontiers of Engineering for Development, which brings together engineers from all disciplines to network and engage with their peers on global challenges.

Initiatives such as the Africa Prize play an important role both in raising the profile of engineering and highlighting the critical role it plays in tackling development challenges. The Academy has, for the second year, taken part in an exciting partnership with HRH The Duke of York's Pitch@Palace series. Last month, the 16 engineers shortlisted for the 2018 Africa Prize had the opportunity to pitch their innovations directly to an influential audience from the worlds of entrepreneurship, technology, media and investment at a special event at St James's Palace.

Research and innovation is one of the UK's greatest strengths, and programmes such as those supported under the Global Challenges Research Fund leverage this world-leading capability to help address major societal issues faced by the world's poorest. The importance of capacity-building programmes for engineers in developing countries should not be underestimated - but nor should the reciprocal benefit for the UK. These partnerships help deliver real and lasting change for communities as well as connecting the UK with outstanding innovators and markets around the world 🔳

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



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# New deals on wheels

#### A hydrogen-powered car-use scheme is part of a burgeoning movement which could make car ownership a thing of the past, writes Andrew Wade

ars have traditionally always been more than just vehicles. They have been objects of desire, inspiring devotion, conferring status, penetrating the psyche of our collective consciousness. But attitudes about mobility are shifting, and car ownership is no longer the exalted goal of times past. Increasingly, people just want the best possible solution to get from A to B, with waning emotional attachment to the method of travel. In order to reflect that, the car industry may have to

radically adapt its practices.

The automotive business model hasn't really changed since the days of the Model T. Manufacturers produce cars which are sold more or less directly to customers, who then become the outright owners. Leasing has grown in popularity recently, but exists predominantly as a mechanism to reduce the barrier to purchase. Ultimately, the industry's business model depends on obsolescence and volume, and is implicitly inefficient as a result. What's more, it's a model that precludes OEMs from the bulk of expenditure over a vehicle's lifetime.

"When a car is sold, less than 40 per cent of the revenue generated by that car in its life goes to the manufacturer," Hugo Spowers, chief engineer and founder of Riversimple, told *The Engineer*. "Sixty per cent goes elsewhere, and they can't access it, whereas we can."

Riversimple, a start-up based in the heart of Wales, is taking an entirely new approach to mobility. Its hydrogen-powered vehicles, spearheaded by the two-seater Rasa, will remain the property of the company throughout their lifetime, with Riversimple offering mobility-as-a-service (MaaS). Customers will pay a monthly fee – comparable to the current monthly cost of car ownership – that will also cover all fuel. This incentivises Riversimple to focus on efficiency, investing upfront to reap rewards further down the line.

"Efficiency does cost," Spowers explained. "It's more expensive to make a more efficient car. It eats into your profit margin, so the industry can only lobby against those regulations and cheat when they come into force, which we've seen recently. We need to make efficiency profitable, and that is the single biggest change we need to see to improve the environmental impact of transport."

According to Spowers, the automotive industry is fundamentally flawed, based on a model that encourages waste.

"Your interests are obsolescence and high running costs, because that's what you make your money out of," he said.

"I simply don't see how you can ever have a sustainable industrial system



The Rasa is designed to operate locally, with a range of 300 miles. Picture: Anthony Dawton

based on rewarding industry for the opposite of what you're trying to achieve. It's just fundamentally not very clever."

What's required, Spowers says, is a more holistic approach; a cradle-tograve perspective on the life of the car. If obsolescence no longer underpins the market, this encourages different methods of design and manufacture, methods that work for the benefit of all parties as well as the environment.

Prof Raj Roy has been beating this particular drum for many years. He heads up Cranfield University's Through-Life Engineering Services (TES) Institute, an organisation dedicated to research and education on how to manage high-value products for the duration of their existence.

"At Cranfield, we're looking at engineering for life, and I think for us that's really important," said Prof Roy. "So when you engineer a product, you need to think how that product is going to behave for the entire lifecycle. That's number one. Number two is how you can increase life. That's also important for us because we want to reduce resource consumption and, for that, extension of life is important."

The emergence of TES has been driven by a wider trend across industry called servitisation, whereby services are sold to customers instead of products. Examples of this can be seen everywhere. Companies like Microsoft, that once sold Windows packages by the millions, now operate predominantly via subscription models, selling software as a service (SaaS). Where Xerox once relied on sales of printers and toner, it now provides managed print services and document management solutions.

Servitisation has grown in popularity recently, but it's been around for a long time. As well as selling engines, Rolls-Royce has been selling Power-by-the-Hour for over 50 years. By offering engines for a fixed-cost-per-flying-hour, the interests of the company and its customers became more closely aligned, with Rolls-Royce only paid for engines that were running. The incentive became to design for the long term, extending the overall lifetime of the engine. Designing cars for the long term – and dealing with the associated drop in volume – is something the car industry needs to prepare for, according to Prof Roy.

"Car design has to change to survive such a long lifespan, in terms of mileage," he said. "We're talking about half a million to one million miles per car. That's one challenge: how to design cars for that.

"Number two – how do you cope with reduction in volume? The automotive sector today very much depends on volume, and car production volume – or the number of parts – is going to go down significantly in the future, because of mobility as a service. Each car will last longer, and the car will need to be designed in such a way so that new technologies can be introduced as time progresses."

This long-term mindset has been adopted by Spowers and Riversimple from day one. From the earliest drawing-board concepts to the latest engineering decisions, everything is geared towards the overall efficiency of the car and the system in which it operates.

"In our case, we design knowing it's going to be on our balance sheet for its lifetime," said Spowers. "A typical car lasts for 13 years. We model around 15 years because it sounds credible, but in fact we think we can get a longer revenue stream out of it than that."

Riversimple's MaaS model for the Rasa will see customers essentially leasing the cars under contract for a set period of time. However, rather than individual ownership, many believe the future of MaaS lies in car-sharing services where mobility can be accessed on demand. Companies such as Zipcar are already providing these services. The US firm – bought by Avis in 2013 – has brought car-sharing to more than 100 cities around the world and claims to have over one million members.

Zipcar's UK fleet includes hybrid VW Golfs, but newer entrants to the car-sharing market are going pure electric. In Paris, the Autolib' scheme uses a network of a few thousand Bolloré Bluecar EVs to deliver MaaS. Similar to the bike-sharing schemes found in most major cities today, users can pick up and drop off the cars at various points. But if the network is to function properly, a critical mass of vehicles must be available at any given time.

"One of their selling points is that you are never more than 100m from one of their cars," explained Dr Paul Nieuwenhuis. "But it has to be waiting for the system to work."



Nieuwenhuis is co-director of Cardiff University's Centre for Automotive Industry Research and the university's Electric Vehicle Centre of Excellence. He agrees with Professor Roy that the automotive industry is moving towards a completely different business model, though he isn't as certain that a drop in production volume will automatically follow.

"Some people have started to dig a bit deeper and are saying that in order for these shared cars to be available as and when you need them, you must have quite a few sitting around waiting for someone to need them," Nieuwenhuis said.

Car sharing is undoubtedly on the up, but just how much penetration it will have still remains to be seen. It's unlikely to eclipse outright ownership anytime soon, though it certainly has the potential to impact the bottom line of OEMs, regardless of how future driving habits evolve. Electrification, connectivity and autonomy are all precipitating change. Manufacturers are operating in a space that's in almost continuous flux, and one in which their traditional business models may no longer be fit for purpose.

"Even if we only consider the move to electric, this means quite a different business model," said Nieuwenhuis. "One has the feeling that only Tesla has really appreciated that. Tesla has a fully integrated model which involves getting into the energy generating end, energy distribution, battery technology, making the vehicle and charging.

"So they're putting everything together, whereas most of their competitors are focusing on the car rather than the system that you need. And I think they'll come under increasing pressure to take a different approach beyond the car, as it were."

Advances in materials are another key agent of change. The chassis of Riversimple's Rasa is a carbon fibre monocoque that weighs less than 40kg. With the company on the hook for the hydrogen that will power it, the weight is crucial. Equally as important is the fact that it will never rust, with everything about the vehicle geared towards longevity and value through to end-of-life.

"If it's going to be our car at end of life, we design it for maximum recovery of value," explained Spowers. "So that



**01** Riversimple's Rasa will be available to customers via mobility-as-a-service (MaaS) contracts. Picture: Anthony Dawton

**02** Paris's Autolib' programme has seen EVs providing MaaS across the French capital for more than six years

**03** The RS Van concept – Riversimple's next vehicle – will be a last-mile delivery van

end-of-life liability, which the industry regards as about 200 quid, in our case becomes a credit. We call it zero in our financial model because we don't know how much it is, but it's certainly a positive number.

"The car has no moving parts other than the wheels. There's no metal-to-metal wear, no lubricants, no oil changes and so on. And there's also no corrosion, because all the structural materials are inert. So it's designed for a much longer life, and that long tail of revenue is much longer than I think the auto industry acknowledges."

Nieuwenhuis agrees. According to him, the big players in the auto industry are simply not set up to think in this way. Despite many OEMs making significant moves in electrification and autonomy, a century of competition based on volume has left them ill-equipped for a future that could see their modus operandi so profoundly disrupted.

"The industry is totally focused on the new car sale, but loses interest once it goes to a second, third, fourth, fifth owner," he said. "But that is most of the market, that used-market, and OEMs are not geared up to deal with that. Once you start going to a model where the minimum use phase of a car is not 15 years but 30 or 40 years, you need a completely different business model, because you're not going to be able to run a business based on replacement demand.

"You have to engage with that use phase. You have to move to either a mobility service business model or something that at least manages that use-phase over several decades."

Remaining engaged throughout that use-phase is core to Riversimple's strategy. Spowers describes the Rasa as a car that is 'local', but not restricted to being urban. People living outside towns and cities, where public transport is usually sparse at best, are generally more reliant on cars.

A single hydrogen filling station in a small city like Oxford – or a town such as Abergavenny that will host a Rasa trial later this year – could easily support 50 vehicles operating within a local radius. What's more, the commercial proposition of that station is much stronger, backed by the knowledge that there is a geographically secure customer base.

"The car's got a 300-mile range, not for a 300-mile journey, but to be at least a week's use of fuel," said Spowers. "And that supports a market with a radius of about 25 miles around a market town or a small city, with one filling station creating the commercial market.

"If we put 50 cars into that market, they'll all use that one filling station, so the investment case for the filling station is much, much stronger. Then you can grow your market one filling station at a time and incrementally grow the skeleton of a nationwide network. Then at some point in the future, when there's enough hydrogen around, we'd launch an intercity-capable five-seat car."

That motorway-ready car would require a network of around 300 filling stations around the country, so it's not something that will be seen in the near future. However, the company has more immediate plans to add to its fleet. The next concept in the pipeline is another 'local' vehicle, but for last-mile delivery rather than personal mobility.

"This will be a lighter vehicle with a lower payload than comparable vehicles, but it will be very, very efficient," claimed Spowers.

"It will use virtually exactly the same powertrain as the Rasa, we can make it in the same plant and also, critically, use the same infrastructure logic."

Ultimately, Spowers wants to help bring about a new type of mobility system - one that's cleaner,

operates more efficiently, and manages resources through all stages of a vehicle's existence

> The end result, however, could be anathema to the rest of the automotive industry.

"We're probably the only car company in the world who not only hopes never to sell a car," he said, "but thinks there are actually far too many cars on the planet."



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#### feature | powertrain technology

# Drive for a digital future

A UK firm is testing technology to digitise the last remaining analogue part of the internal combustion engine. Jon Excell reports

ajor leaps in mature technologies are relatively rare occurrences. And there are few more mature technologies in widespread use than the internal combustion engine, where gains in efficiency and performance tend to be

incremental rather than earth-shattering.

But now a small automotive consultancy in Learnington Spa claims to have bucked this trend with the development of an innovative digital valve-train system that it says could ultimately improve a petrol engine's fuel economy and reduce its emissions by as much as 20 per cent.

Camcon Automotive's Intelligent Valve Actuation (IVA) technology, which has been under development for the past six years and has now completed rigorous dynamometer and road trials, effectively digitises one of the last remaining analogue systems on a combustion engine by replacing the camshaft with valves that are opened and closed by a set of digitally controlled motors.

Mark Gostick, the firm's chief operating officer, who runs the company with CEO and engine veteran Roger Stone, told *The Engineer* that the "unprecedented" level of control the technology brings to valve timing, lift and period could breathe new life into the IC engine.

Explaining the system's operation, Gostick said that it replaces the connection to the camshaft with a set of torque dense electric motors that actively drive the opening and closing of each individual valve (a so-called desmodromic mechanism). This means that the system dispenses with the valve spring traditionally used to close the engine valves, which, said Gostick, significantly reduces the amount of power it needs and enables the valves to be far more precisely controlled.

"Every other element of the combustion process – fuel and spark – have been under control for some time," he said, "but the air charge, which is in many senses the most important, has still essentially been under analogue control." He added that the system has major advantages over many existing efforts to control the valve train. "Even the best variable valve trains are limited in the flexibility you have to open the valve at a point in time when the engine wants it rather than when the valve train can give it to you. This system enables you to set the timing, the period, the trajectory, the shape of the valve event and control it in real time."



During trials of the technology Camcon worked closely with Jaguar Land Rover (JLR) to fit the system to one of its most advanced petrol engines, the two-litre, fourcylinder Ingenium engine. After 1,000 hours of dynamometer testing, the system demonstrated fuel economy improvements of 7.5 per cent, a figure which, according to a paper on the technology presented at the 2017 Aachen Colloquium, only scratches the surface of the technology's potential.

Gostick said that these trials have demonstrated that the technology could be relatively simply applied to existing engine designs, a key point for OEMs wary of investing in new engine development programmes.

"We want to show that you don't have to develop a



specific engine around this; you can graft it on to the top of an existing engine design and still get benefits," he said.

The technology is also claimed to hold great promise for new engine designs, in particular smaller, highperforming engines that could be used alongside electric motors as part of a hybrid powertrain system. "Because IVA makes an engine much more efficient, you can potentially make the engine itself smaller, further increasing the space in the engine bay, further lending itself to hybrid applications," said Gostick. Even more space for electrification components is freed up by the fact that the system dispenses with the need for a timing chain at the front of the engine, he added.

Although the concept has been under discussion for a number of years, Gostick said that it has only recently become technically feasible. This is thanks to advances in a range of underpinning technologies such as rare-earth magnets that have enabled the team to build the required torque dense motors; the emergence of electronic components able to operate in the high temperatures of an engine compartment; and, of course, fast cheap processors.

"Incremental improvements in all the underlying technologies enables you to put them together in a system in a way that hasn't previously been possible and at a cost which can be made acceptable to the auto industry," Gostick said.

During the trial period, which has also seen the system installed on a demonstrator vehicle supplied by JLR, the team has learned many lessons about the technology's potential. "We've found we can induce air charge motion, which gives you more efficient mixing and therefore better combustion; we can reduce pumping losses because we can open the valve at the appropriate time for the appropriate amount and we can also reopen the valves – there are some combustion processes where you need to be able to inject bits of exhaust as you open the inlet valve. We've demonstrated that we can do those valve motions which aren't possible with a mechanical system which still retains a link to the crank."

To allow industry to further explore the technology's potential, Camcon is now developing a single cylinder engine equipped with IVA to enable automotive development departments to carry out combustion research. "What we've got is a new tool which can start a lot of combustion development and enable you to start thinking about how you can implement some of these combustion strategies that people have known about for a long time but haven't been able to do," said Gostick.

In terms of commercialising the technology, he estimates that the route to production will take around five years. Alongside Jaguar Land Rover, which has supported the development of the technology, a number of OEMs and Tier1 suppliers have also expressed an interest, he added.

If a manufacturer were to take the plunge and put the system into production, Gostick believes it has a good chance of becoming huge. "As with a lot of technologies it either does or it doesn't," he said.

"If it does it stands a good chance of being almost ubiquitous because the impact it can have is significant across the whole IC engine. " ■ "Because IVA makes an engine much more efficient, you can potentially make the engine itself smaller"

Mark Gostick

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#### interview | anthony finkelstein

# At the front of the Q to thwart enemies

Stuart Nathan finds the chief scientific adviser for national security far removed from a Bond techie and passionate about British research

agazines like *The Engineer* arrange interviews in two ways. Sometimes we contact organisations to request interviews with people who we think might be interesting, and sometimes they are pitched to us. In this case, the Royal Academy of Engineering got in touch and asked if we'd like to speak to Anthony Finkelstein.

He is the chief scientific adviser for national security, we were told. "Basically, he's like Q from the *James Bond* films."

This is not the sort of introduction that one can turn down. Meeting Finkelstein in a basement conference room at the Academy's headquarters near St James's Park (a time-honoured rendezvous for Cold War spies, as John Le Carré told us), I wasn't sure whether to expect the sort of bumbling-but-brilliant character portraved by Desmond Llewelyn in the original films, the donnish-but-sarcastic type played by his successor, John Cleese, or the unassuming-but-penetrating new version of Ben Whishaw. Finkelstein resembles none of these; he is a tall, slightly gangly man with a taste for floppy caps and warm knitwear, and has a measured manner of speaking that indicates he is considering every word carefully. He is also quite adamant that he isn't Q. When asked whether there is, in fact, a Q at all, he replied that he can neither confirm nor deny it. "But if there were one," he added dryly, "she'd be doing a quite marvellous job."

Finkelstein is a software systems engineer by profession, holding the chair in the discipline at UCL and based at the Alan Turing Institute, the UK's national institute for data sciences headquartered at the British Library. However, he added, we should not necessarily draw any inferences from that about the nature of the science he advises on. All other government departments save one have chief scientific advisers (CSAs), he explained (the Treasury has a chief economist). "We try to have a kind of mix among all the CSAs of different disciplines, so that when we have a multidisciplinary problem we can call on a range of people. We have physicists and materials scientists and people who have control and robotics experience, and a statistician, so I'm the sort of resident computer scientist."

Finkelstein works across the range of government organisations that bear upon national security. Formally, his affiliation is to the government office for science, but he deals most often with the Ministry of Defence, the Home Office and the police. His remit covers the whole technology spectrum, but is not concerned with weaponry or what he describes as "a large defence infrastructure". The role of CSA is both proactive and reactive. "I run a large national security-related research programme, and I have creative input in that," Finkelstein said. "But also people in the national security arena bring problems to me which I try to use science to address. The other people who bring me problems are our adversaries; I look very closely at what they are doing and look very closely at how any technologies provide a threat or an opportunity to improve the effectiveness and efficiency of our national security." The nature of those adversaries is as various as the technologies Finkelstein deals with. "They range from lone actors and spontaneous volatile extremists through to terrorist organisations, or 'hostile non-state actors' as they are sometimes called, to states which wish us and our values ill," he explained.

Although not all of the technologies with which Finkelstein is concerned are in the digital domain, because of his background he has a particular interest in the computer science aspects of national security.

One thing that is particularly interesting to him at the moment, he said, is privacy-enhancing technologies "both for the opportunities they provide for national security to be able to maximise its function while minimising intrusion, but at the same time, I'm really interested in the exploitation of these privacy-enhancing technologies by our adversaries to hide bad stuff".

Some of these privacy-enhancing technologies include statistical disclosure control, which is a technique intended to ensure that when a survey or administrative data is analysed, no person or organisation can be identified from the results; privacy-preserving data mining, a related technique that tries to ensure that while knowledge can be extracted from data, that knowledge should not include information about individuals or organisations that should be kept private; and another related technology known as homomorphic encryption, which is computing unencrypted data, so inferences can be drawn without decrypting private information.

In the case of such technologies, Finkelstein's role is to encourage research that will help provide tools for providers of critical national infrastructure to manage related data and ensure that it is kept as secure as is feasible.

One thing Finkelstein is particularly keen to stress is that even when security structures seem to be crude, the science that goes into constructing them or optimising them is often considerable. The most visible pieces of the security apparatus that the general public see are probably bollards and barriers protecting sensitive buildings or places where

"I'm really interested in the exploitation of privacy-enhancing technologies by our adversaries to hide bad stuff"



crowds gather. "Designing a really good bollard is extremely difficult because the more deeply you embed it the more expensive it is, and you have to withstand all sorts of force," Finkelstein insisted. "Actually, vehicle mitigation is really difficult, complex and quite hi-tech. The point is, you always want to use technology appropriately for the challenge you are facing, and that isn't always the most elaborate solution. It's the best solution to meet the requirements."

Another part of security procedures that many people know about is the use of spotters surveying crowds in airports or sometimes in video feeds to identify patterns of suspicious behaviour. "There is an astonishingly complicated bit of behavioural science research that's gone on in order to underpin changing the way we do things in public spaces. It may appear crude but if it does that belies the fact that it is based on a lot of very serious behavioural sciences."

As part of ongoing efforts to develop technology in the national security sector, Finkelstein and the Royal Academy of Engineering have launched a post-doc programme to help identify exciting and important research that might make a contribution to the UK's national security and that of our allies. "We are also "The national security community now knows we can't do everything behind the barbed-wire fence" interested in developing the UK capability in many of these areas of science and engineering. We want to encourage work on topics which are likely to make us safer, while developing the tech ecosystem around networks to our collective benefit."

Partly inspired by a similar successful scheme in the US, this programme is a response to a problem which will be familiar to many in the industrial R&D community. "Things have changed, technologies are a lot easier to access and the global science base is a click away, so the government is very conscious that science is globalised, and there is a whole range of states that now have advanced science and are moving at our rate if not faster. The national security community now knows we can't do everything behind the barbed-wire fence. We are only going to be able to keep up with exponential technlogy advances and with fast-moving agile adversaries if we exploit the full value of the innovation community and of the open science and technology community. It's difficult and counter-cultural for us to achieve that openness - we prefer in general not to tell people about our capabilities or our lack of capabilities, but on the other hand the brightest people don't necessarily work for you, so we have to reach out."

# We tried to crash it... but we failed

The safety-first Subaru XV proves that compact crossovers can handle more than just the school run, writes Chris Pickering

> ubaru has always done things a little differently, so while most compact crossovers are essentially front-wheel drive hatchbacks on stilts, it's no surprise that the new XV is made of sterner stuff. It comes with

permanent all-wheel drive as standard, plus Subaru's trademark boxer engine configuration – once synonymous with the brand's rallying exploits.

Perhaps less appealing to traditional petrolheads will be the Lineartronic continuously variable transmission (CVT). But this is also something of a Subaru trademark, offered on just about all models in the company's home market. In fact, the option of a manual gearbox was dropped with the launch of the new XV at the beginning of this year. So too was the diesel engine, leaving just the petrol models (in 2-litre 156 PS or 1.6-litre 114 PS form).

Externally, it looks a lot like the old XV. Under the skin, however, this is a clean sheet design; the second to be spun off the new Subaru Global Platform, which reputedly cost the firm over \$1bn (£720m) to develop. It's a steel monocoque, utilising hot press moulding for key areas and featuring a significant percentage of high strength and ultra-high strength materials in its construction.

Improved joining techniques and larger reinforcement channels in the floorpan also help to boost the structure's rigidity, which is now up by 70 per cent in torsion and 90 per cent in lateral bending. These channels have also been designed to provide a smoother load path for crash forces, which has contributed to the XV's best-in-class Euro NCAP safety ratings.

You don't have to crash the XV to feel these benefits, though. Subaru was brave enough to send us out onto a slalom course in the old XV and then back-to-back with the new model. The improvements in structural rigidity and steering precision were palpable, and Subaru claims you can also feel these in more mundane situations, such as while reacting to crosswinds.

The new, stiffer structure is said to better-resist the transfer of sound and vibration, making it a more refined place to spend time. What's more, Subaru points out that the four-cylinder boxer engine configuration has superior secondary balance to a normal inline engine.



"The improvements in structural rigidity and steering precision were palpable" That's as maybe, but the 2-litre naturally aspirated unit still needs to be revved quite hard to make progress. It can feel a tiny bit strained in comparison to the torquey turbocharged opposition (petrol and diesel), not helped by the CVT, which causes the revs to flare as you put your foot down.

To be fair, Subaru's Lineartronic system is smarter than the average CVT. For a start, it uses a chain rather than a belt. This runs between two hydraulically adjusted pulleys to vary the overall ratio. A hydraulic torque converter is used to couple the engine to the transmission, with a lock-up damper to smooth out any torque fluctuations. The idea behind this two-stage approach is to reduce the lag and surge effects found on traditional CVTs. It is a marked improvement, but it still doesn't feel (or sound) quite as natural as a conventional automatic gearbox.

For keen drivers, Subaru has also included a manual mode, controlled by a pair of steering wheel-mounted paddles. This introduces a series of artificial steps in the transmission ratio, designed to mimic a conventional six-speed gearbox. Again, it



works surprisingly well, although the changes are still noticeably slurred and the end result feels like an approximation to a conventional gearbox rather than a true facsimile of one.

Ultimately, the CVT doesn't feel like it adds a great deal. In theory, its ability to hold the engine at an optimal speed and load point should improve both performance and economy. In reality, the 2-litre model's claimed figures of 0-60mph in 10.4 seconds and 40.9mpg won't win you any bragging rights. One of the reasons the brand says it has stuck with the boxer engine is the exceptionally low centre of gravity that comes from arranging the cylinders horizontally about the crankshaft. This helps to make the XV feel very reassuringly car-like to drive, despite its elevated ride height. You'd never quite call it sporty, but it is agile and responsive.

Another unique benefit, we're told, is that the low, flat engine is designed to submarine under the passenger compartment in the event of a major head-on impact. While that's not something we wanted to put to the test, we were encouraged to try our hardest to crash – albeit under controlled conditions on an airfield. It was here that we had a chance to sample Subaru's EyeSight system. This is a suite of six different technologies, so-named because they rely on a pair of windscreen-mounted cameras to give the vehicle stereoscopic vision. The highlights include Pre-Collision Braking, Lane Keep Assist and Pre-Collision Throttle Management.

As the name implies, Pre-Collision Braking will apply the brakes if the driver fails to respond to an audible warning of an upcoming obstacle. Tested at around 20mph, the car came to a full halt several feet ahead of the collapsible target. Meanwhile, the Pre-Collision Throttle Management works on a similar principle from a standing start – not actually applying the brakes this time, but dramatically reducing the vehicle's acceleration if it senses an obstacle. The idea is to give the driver time to react if, for example, they pull away in traffic without realising the car in front has stopped.

None of these functions are revolutionary, but they do work well, and the fact they are all standard fit on the XV – along with a number of other electronic aids – has significantly boosted its automotive **subaru xv** 





**01** The boxer engine's low centre of gravity helps to make the XV feel very car-like to drive

**02** The XV has attained best-in-class Euro NCAP safety ratings

safety ratings. Just as importantly, we never encountered any false alarms.

In some respects, however, the XV is at its most impressive off the beaten track. A modest 220mm of ground clearance will ultimately limit its off-road abilities compared to a full-size SUV, but it is remarkably capable for a crossover.

Even on standard road tyres it made light work of conditions that leave most of the opposition stranded. That's particularly true when you bear in mind many of its competitors are sold in frontwheel drive form. Those that do have a four-wheel capability typically only send power to the rear wheels once slip is detected at the front. This can incur a noticeable delay, leading to loss of traction. The Subaru, on the other hand, uses a proper permanent all-wheel drive system, and the CVT transmission means that drive is maintained even while it's changing ratios. The end result is deeply impressive when the going gets tough.

A few idiosyncrasies aside, the Subaru XV does a fine job of blending the capabilities of an SUV with the convenience of a family hatchback. In reality, few will delve into its off-road abilities. So, while the XV's safety credentials and sturdy build quality do add to its appeal, they're unlikely to sway most away from cheaper, more economical and every bit as practical rivals. That's a shame, because the XV is a crossover with real substance to back up its rugged image. And that makes it a bit different.

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#### automation | viewpoint

# How to integrate your robot colleagues

The advantages of automation are understood, but how should employees bring non-human workmates onboard? Here are some tips from Prasad Satyavolu

maller, nimbler robots are symbolic of the agility now required of even longestablished manufacturers. They are gaining popularity in businesses of all sizes, due to their versatility and ability to generate real-time data. It is easy for

manufacturers to become preoccupied with the potential savings they can bring, costing around \$30,000 (£21,700) compared with \$100,000 for a typical rigid unit. However, simple investment is not enough. Manufacturers should consider a range of strategic factors to successfully induct robots into the business, including everything from data capture to workflow design.

#### Bigger is not always better

When integrated correctly, these smaller mobile units can amplify people's skills and strengths to increase workplace efficiency. They are already being deployed across manufacturing organisations, from inserting shock absorbers to drones acting as the eyes of security officers patrolling a vast container yard.

In doing so, the new breed of autonomous co-workers is freeing up humans to take on higher-value work. Researchers at MIT found that human-robot teams working for BMW were approximately 85 per cent more productive than either humans or robots working alone.

Just as robots can free up employees to focus on strategy, robots can also be taught new skills. For example, people are now able to use robotic arms to teach other robots how to pick and pack products, enabling them to go far beyond the task they were initially programmed to do. This helps to eliminate rote tasks for humans.

#### Fitting robots into the data puzzle

Due to the ability of more nimble units to move throughout the factory floor, they are able to collect and share data with different systems, such as those responsible for manufacturing execution and warehouse management. This information can include everything from production line speeds to environmental data including temperature and humidity. These inputs prompt robots to make independent decisions in milliseconds.

Al used to be confined to narrow dimensions of tightly structured information, but now the data streams produced and processed by the smart factory are much more diverse. As teams of mobile robots become integrated into a manufacturer's network infrastructure, Al agents can draw insights from multiple sources to guide robots or humans. Ultimately, this allows them to distil and act upon insights from both humans and robots in real time.

#### Bringing your robot colleague on board

Beyond a solid technical foundation, manufacturers should consider a range of strategic factors to integrate next-generation robots into their overall strategy:

**Re-think workflows:** Introducing autonomous units that can think and interact with a wider ecosystem requires a re-evaluation of workplace structure. Manufacturers should conduct ergonomic studies to envision how experienced, skilled humans could work on a task with smart robots, such as cleaning oil from a part before assembly. Robots and humans will also both require new skills to co-operate and keep up with the latest software.

**Consider social factors:** The introduction of robot companions requires an understanding of social context and how these teams might communicate. To address this, businesses could introduce devices such as smart watches, enabling robots to



instantly flag a slowdown in productivity that a human would not register. As people attempt to manage the new emotions associated with robot-human relationships, manufacturers could even introduce machine colleagues via virtual reality, to build familiarity and simulate tasks. **Create a centre of excellence:** Setting up a centre of excellence can help manufacturers pilot, manage, report on and champion the role of automation across the business. Taking input from employees at all levels, this should be aligned with the needs of the wider business and be led by a senior executive, to ensure that initiatives drive the whole organisation forward.

Start small: Prioritise initiatives based on specific products or market segments. Although some pilot projects may not be suitable for mass rollout, they may still yield vital lessons for future endeavours. It is easy to be caught up in the hype of robotics, but starting small and scaling up gradually will ensure they remain aligned with key business priorities. Build an ecosystem of partners: Such is the complexity of automation, robotics programmes are intertwined with far too many systems for any single company to build or supply a complete solution. To solve this, manufacturers should participate in a cross-industry ecosystem of partners to pool expertise.

Undeniably, the combination of robotic attributes with the experience and dexterity of human workers is a formidable combination set to dominate the manufacturer of the future. As with any change management project, understanding the gaps between the current state and the desired future is critical, before creating a defined roadmap to close them. Most importantly, manufacturers need to understand that the field of robotics and machine learning is constantly advancing, meaning strategies have to be fluid and adaptable. Through human imagination, the establishment of centres of excellence and beginning with small pilot programmes, manufacturers can take advantage of this nascent field.

Prasad Satyavolu is chief digital officer – manufacturing and logistics at Cognizant



#### automation | viewpoint

# Don't let Industry 4.0 threaten your security

With devices connected to the Internet of Things, the risk of cyber-attacks is increasing, so manufacturers must act to protect themselves, says Andrew Cooke

ndustry 4.0 is the next phase in modern manufacturing. The term describes the fourth industrial revolution where, driven by the Internet of Things (IoT), physical devices within industrial plants are being fused with the internet so that processes can be carried out through automation. Industry 4.0 essentially means that manufacturing plants are getting 'smarter' as all physical devices are becoming connected, where they can talk to each other, become more efficient and trigger actions with minimal human involvement.

The benefits from Industry 4.0 are far reaching. Manufacturing plants can see improvements in efficiency and productivity due to the consistent monitoring and computer-controlled assessments, which have the ability to identify issues before they become a problem. Similarly, Industry 4.0 also offers a number of health and safety benefits as human intervention can be completely eradicated in certain processes, particularly for jobs in hostile working environments. The results for many organisations looking to adopt Industry 4.0 could be increased revenues, greater profit margins and even an advantage over competitors.

However, as with any change in working practices, there are also some associated risks which must not be ignored.

#### The disadvantages of connectivity

With Industry 4.0, physical entry terminals all have IoT embedded into them, which ultimately means that they are vulnerable to cyber-attack. While this added connectivity helps improve productivity, it is also a weak point in the network which cybercriminals can take advantage of.

Cybercriminals understand the sensitivity of these networks and are also fully aware of the devastating consequences a successful attack can have – from lost revenues, a fall in profits, irreparable brand damage, or the devastating threat to people and assets. It is therefore imperative that manufacturing plants looking to adopt Industry 4.0 improve security and ensure they are not exposing systems to cybercriminals.

One of the key challenges with cybersecurity within manufacturing plants is that attacks are extremely difficult to identify in operational technology (OT) environments. Consider a plant



where, for an unknown reason, a certain component suddenly stops working. The chances are a cyber-attack is not going to be the first consideration when trying to work out what has gone wrong. In nine out of 10 cases the root cause is likely to be benign. But what about that one time when there was a more sinister root cause?

While monitoring services exist for OT environments, they have limited application due to the necessity for network zones, or segmentation. This means that sensors need to be placed at a number of different layers within the network in order to monitor activity. Another contributing factor is complacency, even if network traffic is being captured. Many organisations are completely focused on getting systems up and running again, rather than mining through vast data sets to determine categorically what went wrong.

#### Cybersecurity best practices

As organisations adopt Industry 4.0 working practices, cybersecurity is increasingly paramount. With this in mind, here are five cybersecurity best practices to help protect connected manufacturing plants from cyber-attacks:

■ **Default credentials:** Factory set usernames and passwords are a major security risk and provide attackers with a very easy entry point. Before

connecting a device, ensure that these credentials have been reset.

■ Patching: When code flaws – i.e. zero-day vulnerabilities, are found in software, updates will be released. Organisations need to determine how these can be implemented and rolled out to affected devices within the environment.

■ Network maps: Understand the complete profile of the network. This includes defining how OT and Industrial Internet of Things (IIoT) are connected and the risk that exists within the process.

■ Asset identification: Determine what processes and assets are critical to the organisation's ability to operate and what the threat vectors might be. Draw a map detailing processes, correlated against a network map, to get a comprehensive view. You can't manage risks to assets you don't know about.

■ Upskilling: Understand the 'blue-collar' workforce and how working practices have changed. Many now use technology to perform tasks, so make them aware of the cyber threats they face. For example, engineers should not be able to just plug in a USB stick without first checking that it is free of malware and its operating system is up to date. ■

#### Andrew Cooke is Head of ICS Consultancy at Airbus CyberSecurity, a unit of Airbus Defence and Space

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RK Rose+Krieger has expanded its support arm system for its RK monitor mounting with a telescopic support arm (basic length 495mm). In its extended state (720mm), it is designed for monitors, display devices and operating terminals weighing up to 5Kg. With its new swivel arm, RK Rose+Krieger expands its combination options and enables greater ergonomic adaption of end devices to the working environment.

For use as in individual support arm or as multiple support arm systems together in combination with RK monitor holders. This makes them ideal for use in control rooms where multiple monitors and display devices are frequently placed above or next to one another. The support arm telescope enables the quick and easy ergonomic arrangement of any number of monitors in a range of formats.

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# Advanced Manufacturing

### Robots to 'see' metal defects

isual inspections of metallic components could be improved using a robotic system being tested at the University of Sheffield's Advanced Manufacturing

Research Centre (AMRC). Researchers at the AMRC are testing the automated visual inspection system, which has been developed by Canadian automation specialist AV&R, at its Factory 2050 facility. The system uses a robot to handle a component that is lit from various angles. The robot rotates the component in front of a camera, to allow the system to obtain photometric data about its surface, and spot any tiny defects that might be present.

The technology allows a

component, such as a turbine blade, to be lit in such a way as to mimic the way humans look at a surface, according to Harry Burroughes, senior project engineer in the AMRC's

"It can take 18 months to train a human"

Harry Burroughes

Integrated Manufacturing Group.

"We're trying to replicate the human ability to detect defects on a non-machined surface," said Burroughes. "The human brain is actually very good at detecting anomalies."

Unlike humans, the robotic system can perform the process repeatedly with the same level of



accuracy and efficiency. A robotic inspection system can also be cloned if a company needs to increase its production capacity in a hurry, while employing a human operator to do the job is far more time-consuming, said Burroughes.

"Training an operator for the inspection process can take around 18 months, whereas we can clone another machine quite quickly to increase a company's rate capabilities."

The team will be investigating how best to deal with the large amounts of data generated by the system, including compressing it into a useable format. They will also investigate augmented reality to present images of the components being inspected by the system to remote operators. **HK**  The component is lit in a special way to allow the robot to inspect it

### Order books buoyant

Manufacturing order and export order books remained above their long-term averages in the three months to February, according to the latest monthly CBI Industrial Trends Survey.

Just under a third (30 per cent) of manufacturers reported total order books to be above normal, with 22 per cent indicating that their export order books were above normal.

The survey found growth broad-based, with output rising in 16 out of 17 sub-sectors, which was driven largely by food, drink and tobacco, plus motor vehicle and transport equipment.

Output growth is expected to ease in the next quarter with 32 per cent of respondents predicting volumes to increase.

The combination of a weak pound and a healthy global economy are expected to keep business buoyant for UK manufacturers.

Sounding a cautionary note, Anna Leach, CBI head of economic intelligence, said: "Many businesses are concerned about future barriers to trade and are looking for clarity over the future relationship with the EU. Remaining in a comprehensive customs union will help alleviate some of those fears." **JF** 

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## **Cell-harvesting technology** to make omega-3 cheaper

Consortium's new process looks to make method of extracting the oils from microalgae more energy-efficient HELEN KNIGHT REPORTS

> he cost of producing omega-3 oils from microalgae could be significantly reduced, thanks to a new biomanufacturing

technique being developed by a UK consortium.

Omega-3 oils have known health benefits, but are typically found in fish, making them unsuitable for vegetarians and increasing the pressure on our already limited fish stocks

Microalgae offer an alternative source of omega-3, but extracting the oils from the organisms has so far proven expensive. That is because separating the algal biomass from water is extremely difficult, as membranes tend to get clogged, leaving manufacturers to resort to energy-intensive centrifuges, according to Dr Adrian Stevenson, technical director at the consortium lead LabXero. and group leader of the Acoustic Wave Physics group at Cambridge University.

"With a centrifuge you have a large drum, and you add your batch of algae from the bioreactor, and then spin it at [high] speed," said Stevenson. "Centrifuges burn quite a lot of power and take quite a bit of time."

Instead, LabXero is developing a process known as acoustic cell-harvesting technology, which consumes considerably less energy.

The technology is based on a filter, which can be incorporated into the fluidics, or plumbing, of the



bioreactor itself, eliminating the need for a separate drum and, thereby, reducing the overall size of the operation, said Stevenson,

Unlike conventional filters, which can become clogged, the system uses resonant sound waves to create an acoustic barrier, like a force field, separating the water from the microalgae.

"It would take the watered algae and stream off a lot of water on one side of the filter, and on the other side it would stream the algae and concentrate it," he said.

To develop the filter, including the equipment needed to combine the acoustics with microfluidics technology, the company is working with engineering consultants 42 Technology.

The ProFlow consortium, which has secured almost £630,000 in funding from Innovate UK for the two-year development programme, also includes omega-3 oil producer AlgaeCytes, which has the UK's largest indoor algal

photobioreactor, as well as Unilever and Cambridge University.

The technology could also be used to cut costs and improve efficiencies in the manufacture of other bio-based products.

The photobioreactor at AlgaeCytes that will be used by 42 Technology and the other ProFlow consortium partners to produce omega-3 oils

#### Leap forward in fuselage manufacture

#### Stelia claims world first after it uses additive technique ANDREW WADE REPORTS

Stelia Aerospace has used additive manufacturing to develop an aircraft fuselage panel with integrated stiffening structures for selfreinforcement

In what it claims is a world first.

the French company used WAAM -Wire Arc Additive Manufacturing - to deposit the stiffening aluminium wire to the inner surface of the 1x1m<sup>2</sup> panel. Currently, the web-like stiffening structures inside fuselages are screwed or welded into place by hand. According to Stelia, the new technique could present an opportunity to rethink and redesign fuselages, removed from the constraints of having to attach the reinforcing lattices at a later stage. "With this 3D additive

manufacturing demonstrator, Stelia Aerospace aims to provide its customers with innovative designs

on very large structural parts derived from new calculation methods," said Cédric Gautier, CEO of Stelia Aerospace. "Stelia Aerospace is therefore preparing the future of aeronautics, with a view to develop technologies that are always more innovative and will directly impact our core business, aerostructures."

Referred to by Stelia as DEFACTO (DEveloppement de la Fabrication Additive pour Composant TOpologique), the two-and-a-half year project was co-funded by the DGAC (French Directorate General for Civil Aviation), as well as partners Constellium and École

Centrale de Nantes. The research is part of a broader investigation into additive manufacturing, which Stelia hopes will result in new designs, weight gains, better integration of functions, lower ecological impact through the use of less materials, and reduced manufacturing costs.

Stelia – which employs nearly 7,000 people around the world designs and manufactures the front fuselage sections for the entire Airbus family, plus central fuselages for Bombardier's Global 7000, and composite parts for Boeing, Bombardier, Embraer and Northrop-Grumman.



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# Why MACH is good for your business

Connectivity, innovation and collaboration will take centre-stage at the UK's biggest manufacturing technology showcase, writes James Selka

ACH 2018, the UK's largest industrial trade show, is a hub for the manufacturing technologies and advanced engineering sectors. The biennial show is also a barometer for confidence in

UK manufacturing, so the fact that we have had to open up more floor space to meet the demand bodes well for the future. Exhibitors and visitors alike will come to MACH 2018 because they know it is the place to get business done.

But why should you visit the UK's premier manufacturing technologies showcase?

Well, innovation shapes the world around us and without the appropriate technology we will not be able to make the products which we need to fashion the future. Digital manufacturing has a big and increasing part to play in this future and the technology being produced has never been so accessible. MACH 2018 is the place to see these innovations in action, the place to discover the power of manufacturing technologies and the engineering excellence that has gone into producing them.

In today's technology-driven business environment, data is a key driver of productivity and efficiency for manufacturers. We are living in an ever more connected world, with customers' demands of their suppliers becoming more complex and more time-constrained. Big Data analytics can enable manufacturers to take an approach to improving the manufacturing process, providing them with information to make informed decisions to enhance productivity. MACH 2018, will provide an unrivalled platform for technology providers to demonstrate their innovations.

The exhibition itself does not have a specific Industry 4.0 area because the theme of connected manufacturing runs through the show. There will be something to make every company think about how they could harness the power of digital to improve; from wholesale transformations to an innovative project run by the Manufacturing Technologies Association (MTA) and the Advanced Manufacturing Research Centre Factory 2050 team which will demonstrate how existing machinery can be digitally 'switched on' for a few hundred pounds.

Running from 9-13 April, MACH 2018 will take place on the atrium side of the NEC, in halls 17, 18, 19, 20, 6 and 7. This combination of halls, the first time they have been used to stage MACH, mean the show will take place in a single uninterrupted space on one level.

This will make the show easier to navigate and provide a unique opportunity to showcase the full range of manufacturing technologies in the UK under one roof.

As well as all the technology on show there is a healthy seminar programme marrying academia with industry. MACH is as much about the transfer of knowledge that comes from having some of the





industry's brightest minds all in one place, as it is the equipment on show. Innovating in a collaborative setting is increasingly recognised as a boost to creativity, with co-working spaces and 'hackathons' set up on the idea that great ideas emerge when people come together.

This is something that trade shows like MACH have known and exploited for a long time. They are places where conversations are peppered with phrases like "That's good, but have you thought about doing it this way...?"

A trade show should be so much more than just temporary warehouse and we believe MACH 2018 will be. So, why not take advantage of this opportunity and experience everything MACH 2018 has to offer?

And bring your colleagues with you. Sometimes I hear the misconception that trade shows are solely the preserve of people for whom buying and selling is their main job within the business. But when an event is as effective an interactive showcase as MACH that is far from the truth. MACH 2018 will have something that should speak to all aspects of your business and that can help to inspire your staff or introduce them to new ways of thinking and doing.

It's a great introduction to the wider world of manufacturing for young engineers to. That is true of those who have started on their engineering journey – who will see a broader range of technology than is available at even the biggest plants; and those who are considering doing so – for whom the education and development zone is tailor-made to inspire.

#### James Selka is Chief Executive of the MTA

■ *The Engineer* is excited to be teaming up with the MTA to publish an online show daily throughout MACH 2018. Visit www.theengineer. co.uk during the show for more details.

This year, MACH will take place in a single, uninterrupted space at the NEC, making the experience for visitors that much better

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# Intelligence quotient

The overriding theme running through MACH 2018 is the vital role that interconnected technology will play in the future of manufacturing. Mike Excell reports

he Manufacturing Technologies Association (MTA) and the University of Sheffield Advanced Manufacturing Research Centre

(AMRC), have together created a feature at MACH 2018 demonstrating cost-effective adaption of Industry 4.0 Technologies by SMEs. The project was prompted by perceived implications among SMEs of high cost and complexity.

The feature will demonstrate up to six separate manufacturing cells, replicating familiar manufacturing environments that have been integrated with Industry 4.0 Technologies. "The Integrated Manufacturing Group at [AMRC's] Factory 2050 and we at the MTA understand that it is vital to cut through some of the jargon and hyperbole around Industry 4.0 and show first-hand the practical advantages Big Data can bring to an SME business," said James Selka, CEO of the MTA.

#### Machining and turning centres

The influence of this holistic approach is apparent in the presentations of the major machinetool builders. Productive complete machining, and 'digital workflow' are core issues for DMG MORI (Stand H20: 490). Its CELOS interface is a key element: first presented in 2017, digital workflows for data-supported production planning and automated tool management will be available for customers as CELOS early this year.

Alongside this, 5-axis simultaneous machining is increasingly being developed as a key technology, with automation and combined milling and turning prominent. The DMC 80 FD duoBLOCK universal machining centre, with pallet changer, is said to be extremely rigid and capable of heavy-duty machining of rotating parts, for instance in aerospace applications. Grinding technology can be integrated, delivering surface finish of Ra < 0.3 µm.

Efficiency and productivity are key themes underlying a sector-led



approach from Yamazaki Mazak (Stands H20: 760, 790), which also presents its suite of Industry 4.0 solutions. The Mazak iSMART Factory works in partnership with SMOOTH Technology – said to be the world's fastest CNC – to improve overall equipment effectiveness and facilitate data-driven manufacturing via the seamless connection of factory and office networks.

Aerospace, one of these key sectors, is the principal market for the UK-built VTC-800/30SR, a vertical travelling column machining centre capable of full 5-axis contouring. The machine was designed for machining extremely long workpieces, or can be converted into two separate work areas, enabling pendulum loading and batch manufacturing. It has an 18,000rpm milling spindle, while a swivelling B-axis spindle head, in conjunction with the NC rotary table, offers full 5-axis simultaneous machining. Machines alongside include the HCR-5000S, developed for high-speed 5-axis aluminium cutting; and the INTEGREX i-400S, popular in the oil and gas industry for its large machining capacity.

Several MACH debutants are presented by XYZ Machine Tools (Stand H18: 640). These include the LR and HD ranges of vertical machining centres; plus the UMC-5X gantry-style simultaneous 5-axis machining centre – the company arguing that it 'moved the goalposts' on price/performance ratios with this machine, available with either Siemens 840Dsl Shopmill or



Heidenhain iTNC 640 HSCI control systems. Table configuration and machine design allow 500mm of Y-axis travel forward of the table when it is rotated 90° towards the rear, allowing larger workpieces to be machined.

Matsuura Machinery (Stand H20: 542) will focus on automation and unmanned machining. The company's pioneering tower pallet automation goes back over two decades, with the introduction of the MAM72 5-axis series. The latest MAM72-35V is equipped with 32 pallets as standard and up to 520 tools, for long periods of unmanned 5-axis simultaneous production.

Citizen Machinery UK (Stand H20: 570) will reveal the next generation of its CNC system featuring touch screen and qwerty keyboard, as a key feature on the new Cincom D25-VIII and -VII sliding headstock turn-mill centre. Operational flexibility is maximised for complex cycles with two gang vertical toolposts each with X-,Y- and Z- axes and one with a B-axis capable of both front and







back machining. The Cincom D25-VIII is configured as a 10-axis sliding headstock 25mm capacity machine which also incorporates the added flexibility of 0° to 135° swivelling B-axis. Moving into Phase 2 of its programme for Low Frequency Vibration (LFV) cutting technology, Citizen is also launching the Miyano BNA-42GTYLFV, a 42mm bar diameter hybrid development, moving headstock turn-milling centre.

NCMT (Stand H19: 640) launches the Mecof UMILL 1500, a portal, 5-axis vertical machining centre with mill-turn and high-speed options. The company also presents the Okuma M460V-5AX vertical machining centre, the latest model, and the first 5-axis machine, in the Genos series. Highly rigid, thermally stable, double column construction is supported by Okuma's Thermo-Friendly Concept applied to both machine structure and spindle.

Other notable machining exhibitors include Heller (Stand H20:470) where the focus will be the group's worldwide drive towards integration of its machine tools and controls into the Industry 4.0 environment; Hurco Europe (Stand H6: 180), marking its 50th anniversary with the launch of two machining centres (cantilever design 5-axis plus 3-axis bridge type) and two new lathes; and Mills CNC (Stand H18: 520) showcasing 16 Doosan lathes and machining centres. Returning to MACH, Geo Kingsbury (Stand H7: 244) will present turning, milling and grinding technology from suppliers including Traub (single- and multi-spindle lathes) and Hermle (3- to 5-axis machining centres). Tornos (Stand H19: 312) will demonstrate its new MultiSwiss 8X26, equipped with eight spindles and eight slides for main operations accommodating up to three tools per slide.

#### **Cutting tools**

WNT – part of the Ceratizit Group (Stand H19: 500) will display cutting tool innovations alongside component examples, enabling visitors to relate products to applications. S-Cut UNI milling cutters feature a combination of an S-curve cutting edge and extremely irregular pitch. The geometry of this solid carbide cutting tool creates a variable helix angle, and an extremely smooth cutting action, which enhances tool life and surface quality, as fewer vibrations are produced during milling. Cutting data can also be increased to reduce cycle times. The irregular pitch of the cutting edges counteracts the induced vibrations - from tool to workpiece to machine tool - caused by entry and exit frequencies when making the cut. The irregular pitch also enables higher depths of cut at large angles of engagement.

WNT recognises the growing importance of face-contact spindles with its BT-FC double contact toolholding system. A key benefit is the increased rigidity generated through taper and face contact, with the additional face contact counteracting any lateral forces, greatly reducing axial deviation. The **01** Mazak's INTEGREX i-800V/8 combines full 5-axis milling with powerful turning operations

**02** Heller's 5-axis HMC Profitrainer training system fitted with Industry 4.0-compatible operator panel

**03** WNT'S BT-FC double contact toolholding system; increased rigidity is generated through taper and face contact

**04** Renishaw's high-productivity machining cell concept, with integrated process control

design also enables extended spindle life and reduced vibration.

Other cutting tool exhibitors confirm the value of integrated or targeted cooling. Horn (Stand H6: 890) launches its DA32 milling system with new, high-performance, diamond-tipped inserts. Highly positive insert geometry ensures a smooth cut, minimising stress on the workpiece and tool. Long cutter life and virtually burr-free machining are ensured, particularly on longchipping materials. Coolant supply ensures targeted cooling of the cutting edges plus safe removal of chips. Also from Horn, its new grooving and parting off blades incorporate internal cooling and are designed for universal use in the production of small batch sizes.

Floyd Automatic Tooling (Stand H20: 620) presents the latest line of Mikron Tool's CrazyMill Cool products, developed for milling small dimensions.

A new four tooth finish milling cutter with shank integrated cooling is available in 1-8mm diameter for depths of up to 5XD in hard materials. ITC (Stand H20: 650) will present new 'micro milling' product extensions; new indexable insert milling solutions from Widia; and product lines from BIG KAISER, the inventor of the BIG PLUS dual contact face and taper spindle system.

#### Additive manufacturing

Matsuura (Stand H6: 762) presents its hybrid 3D metal printing and CNC milling machine, LUMEX. In association with this, Oxford-based OGM, which purchased a LUMEX Avance-25 in 2017, offers a Hybrid Additive Manufacturing bureau service and has successfully used this technology to manufacture conformal cooling channels and injection moulding inserts with cycle time reduction and improved part quality. XYZ Machine Tools (Stand H18:640) has been selected as an official reseller of the HP Jet Fusion 3D printing solution, which can print production-quality parts at speeds up to 10 times faster and at half the cost of comparable 3D printing systems. Renishaw (Stand H20: 150) will exhibit software and systems for producing metal parts; the RenAM 500M will be seen alongside demonstrations of QuantAM build preparation software. Renishaw will



highlight the benefits of its fourlaser system, which offers increased productivity in the most commonly used machine platform size.

#### Measurement and inspection

Renishaw (Stand H19: 430) believes that measurement data are essential to gather information enabling intelligent decision making, to prevent process variation: and that Industry 4.0 depends on connected systems, which are able to communicate, interpret and respond to information in real time. So, as well as exhibiting new and existing products, the company will demonstrate how measurement technologies can be integrated into a manufacturing process to achieve intelligent machining. A highlight is a high-productivity machining cell concept, with integrated process control; the principle is that by monitoring key process inputs, analysing data and continuous improvement, manufacturers can increase accuracy and productivity.

Also to be shown are the latest multi-probe optical interface system which uses a spindlemounted OMM-2C receiver to allow up to three machine tool probes to be installed with optical signal transmission; the latest scanning system for CNC machine tools; intelligent process control software for the Equator gauge; and apps to simplify machine tool probing. The company will also present a non-contact tool setter for machining centres; a multi-probe optical interface system; a new surface finish probe for use on the REV0 5-axis measurement system on CMMs; and enhanced software for the XM-60 multi-axis calibration system.

Measurement specialists exhibiting also include Aberlink (Stand H19: 352), Faro (Stand H19: 140) and Hexagon (Stand H18: 430). Aberlink will be giving a MACH debut to the Xtreme 500 CMM. With a measuring range of 500 x 500 x 300mm, it is based on a hexapod



**05** Spindles on the Tornos Multi-Swiss 8X26

**06** XYZ's 5-axis machining centre delivers attractive price/ performance ratio

design using linear motors and mechanical bearings. It maintains its accuracy at fast measurement rates and does not suffer from the accumulative dynamic inaccuracies that occur in conventionally designed CMMs. FARO will introduce a new portable CMM, the Quantum S Arm, which allows manufacturers to easily verify product quality by performing actions such as 3D inspections, dimensional analysis, CAD comparison, tool certification, and reverse engineering. Now with the FARO FAROBlu Laser Line Probe HD, the Quantum S delivers measurement consistency when performing both contact and non-contact scans; it enables users to capture more in richer detail at an increased speed.

A nimble, large-scale portable laser scanner will be among products launched by Hexagon. The Leica Absolute Scanner LAS-XL

offers a scan-line width of up to 600mm, measurement stand-off

distance of up to a metre, and accuracy to within 150 microns. Hexagon says the expanded measurement field and point acquisition rate means components and assemblies such as large blade surfaces can be fully digitised faster than ever.

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#### Grinding and EDM

Jones & Shipman (Stand H20: 875) represents all Hardinge grinding brands in the UK and at MACH 2018 introduces the Kellenberger 100 concept. Modular configuration has helped to optimise costs: the machine shown will be the 1000mm between-centres variant equipped with a WeFlex automated load/ unload system, which can be fitted to any Kellenberger 100 derivative. Also featured is the latest version of the UK-built Suprema Easy cylindrical grinding machine. This multi-purpose machine can process high-volume production grinding work or fulfil high-precision small batch quantities and one-off work (eg. in tool room or prototyping environments). A real advantage is the speed in the set-up of dressing and grinding cycles via specialist 'Easy' graphical grinding software, utilising touch screen technology.

New EDM products from Sodi-Tech (Stand H19: 112) will include Sodick's ALC400G wire eroder and an automated manufacturing cell combining the die-sink AG60L with an Erowa Robot. The ALC400G, incorporates Sodick's latest digital innovations, including its Smart Linear and Smart Pulse technologies, in a small footprint machine; and is said to demonstrate significant advances in cutting speed, accuracy and surface finish, made possible through the use of Sodick's 15 years of linear motor technology expertise. The AG60L is one of Sodick's most popular die sink machines for precision machining large components. Three-sided automatic rise and fall work-tank makes the machine suitable for automation, hence its appearance at MACH 2018 with the user-friendly, small footprint Erowa Robot Compact 80.

EDM machines on show from GF Machining Solutions, (Stand H20: 460) include two AgieCharmilles wire EDM machines – a CUT P 550 and a CUT 1000); and an AgieCharmilles FORM P 350 EDM die-sink machine integrated with a System 3R WorkPartner 1+ automation system. At the heart of the CUT P 550 machine is a new, intelligent IPG (Intelligent Power Generator) that improves cutting performance by 20 per cent. It also features a number of 'onboard' automation solutions that improve





1 Tooling arrangement on Citizen's D25-VIII sliding head mill-tune centre

2 TNC controls from Heidenhain with Connected Machining offer solutions for networking and data exchange

**3** DMG MORI's CELOS interface for data-supported production planning



machine-tool utilisation and uptime as well as reducing operational costs.

#### Software and controls

SolidCAM UK (Stand H17: 640) is set to open a new technology centre to enable customers to understand the complete manufacturing process. The company's iMachining is said to be particularly effective on hard and difficult to machine materials such as Inconel and titanium: claims are made of speed improvements of up to 90 per cent. SolidCAM also incorporates powerful 5-axis machining and mill/turn capabilities, with limitless capability in terms of the number of axes it can control and synchronise. Open Mind (Stand H17: 620) will launch the latest edition of hyperMILL, Version 2018.2, providing demonstrations on how intelligent production can fit into the machine shop via the hyperMILL VIRTUAL Machining Center package. Built with Industry 4.0 in mind, the new simulation solution creates a virtual rendering of reality in the machine based on NC data; it generates a bi-directional communication link between the machine control and the hyperMILL VIRTUAL Machining Center.

Central to its Industry 4.0 presentation, Heidenhain (Stand 18: 545) will demonstrate its Connected Machining system of production, in which all work steps are digitally networked via its TNC milling control. By linking the CNC system into a manufacturer's network via Ethernet, design, programming, simulation and production planning staff as well as machinists on the shop floor are able to access all order and job-related information.

And this is pretty much where we came in. The emphasis from the software and controls specialists underlines this year's MACH message: look for efficient exchange of data right through to the production and despatch of components – and thus embrace advanced manufacturing driven by intelligence.



#### advanced manufacturing | viewpoint

# Cyber-attacks could cripple manufacturing

The new generation of engineers needs to rise to the cybersecurity challenge and design protection into everything, writes Prof Raj Roy

he defence secretary's recent warnings of increased cyberwarfare from nation states and other actors, determined to threaten the UK's infrastructure, must be a wake-up call to the engineering profession. As we

rightly reap the benefits of advanced technological interconnectivity and the rise of Industry 4.0, we must also be vigilant to the dangers that we face now and in the future. Cybersecurity can no longer be an optional extra for engineers; it must be a core competence of the profession.

When you think of warfare, what do you think about? Planes, tanks and ships? While still relevant, this is becoming outdated. An attack on a nation's infrastructure is increasingly likely to come from a cyber-attack. Imagine the capacity of an aggressor to affect a nation's manufacturing plants and machines, to compromise the security of products, production lines and supply chains.

Engineers need to focus on not just developing and maintaining technology, but increasingly need to understand and predict cybersecurity threats. But what do we mean by cybersecurity threats? Too many people think of cybersecurity as a virus on our computer – "it's ok, my company's IT department is in charge of the firewall and I have got the latest anti-virus software installed." It is much more than this.

As engineers we specialise in bringing component parts together, often from across the world, to develop a new product. There are many questions we now have to ask ourselves. Do we understand the security behind those components and how secure they are during their lifecycle? How secure are the materials we are using and can they stand up to threats not just now but in the future?

The Anti-Counterfeiting Forum estimates that counterfeiting could cost the UK economy as much as £30bn and 14,800 jobs. They warn of everincreasing counterfeit electronic components entering the UK, particularly concerning OEMs. We are becoming more aware of the threats but are perhaps less aware of the solutions.

At Cranfield, we are determined to change this. We need to grow the next generation of engineers to be cyber-aware and reskill engineers to understand these very real threats. Our recently



launched MSc in cyber-secure manufacturing aims to train and retrain engineering professionals to understand these issues. The key feature of our work, whether it is teaching or research, is that we develop our offering alongside industry. An example of this is our partnership with Atkins to appoint a new professor of secure engineering.

These challenges will not be solved by people working alone, but by all of us working together. Cyber-threats affect us all whether we are in academia or industry, whether we are an SME or a global corporation. We all need solutions to these common threats. For me, there are four key areas where we need to work together to establish common solutions as an industry: materials security, engineering systems security, systems-ofsystems security and behavioural security.

In order to have the confidence of our customers, engineers will need to have a much greater understanding of the materials that we are using. The creation of digitally secure materials that remain secure throughout a component's full lifecycle is paramount. For this to happen we will need the functionality to be able to constantly reprogramme in order to meet current threats.

It is not only the materials and components we use, but also the engineering systems that operate them. How can we take advantage of distributed ledger technology, self-learning (AI) and pattern recognition approaches to provide updatable protection and the ability to implement rapid threat-response strategies? If we are to create these secure engineering systems, then we also need to understand much more about the behaviour of threatened systems and components. We need a systems-of-systems approach that allows us to understand much more about what happens when one part of our technology is threatened and the impact of that threat on all the other components. Using flexible software-defined networks and secure Internet of Things approaches, we need engineers who can design systems that isolate threats, still maintain a working system and try to self-heal and learn.

A lot of what we think about in cybersecurity is the threat from afar, but how do we protect against human error? Something missed at the design stage or, even worse, deliberately compromised at the design stage, could have a devastating effect. Behavioural psychology and systems thinking can allow us to understand individual and corporate behaviour and map weaknesses and generate monitoring and intervention strategies.

As Industry 4.0 is realised, we must develop engineers that not only understand how to unleash the potential that it brings, but also understand how to counter the threats that are being created. 'Security by default' must be our watchwords, if we are to not only maintain and improve productivity, but also safeguard the nation's infrastructure, which has engineering at its heart.

#### Prof Rajkumar Roy is director of manufacturing at Cranfield University

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# **Meet the** co-bot colleague

Collaborative robots are transforming production processes and coming down in price, reports Mike Farish

n the Brooklyn district of New York, Voodoo Manufacturing employs some 30 people in a business that operates around 200 desktop additive manufacturing machines (mainly Makerbot Replicator 2 devices) to produce thermoplastic parts for a variety of customers. Those customers range from marketing operations wanting promotional items to engineering companies wanting support in both prototyping and initial production runs without incurring 'hard' tooling costs.

But according to chief technology officer Jonathan Schwartz, in all cases, the company's key value proposition is that its efficient use of low capital cost equipment enables it to compete with injection moulding on price for production runs between one to 10.000 parts.

Schwartz added that even though the company was only set up three years ago, it soon decided that the business model was too restricted and that its aim must be to become equally competitive in "high-volume" manufacturing, which in effect means for production volumes up to "100,000 parts".

In turn, that meant reducing its own costs by "90 per cent" and, as it examined its own processes to

Jonathan Schwartz identify target areas for appropriate measures, it zeroed-in first of all on

"We have a 50 per

cent utilisation

of our additive

machines on a

24/7 basis"

"harvesting": the removal of the plates carrying completed parts from machines and their replacement by a new one.

In the early days of the company, he explained, this was carried out purely manually by shopfloor technicians, so that "if there was no-one available it did not happen and the machine stood idle".

It was a situation ripe for reaping the benefits of automation, and accordingly, just a year ago, Voodoo's employees got a new colleague - a six-axis UR10 'collaborative robot' with a maximum payload of 10kg from Danish company Universal Robots, representing an investment of roughly \$45,000 (£32,000). Since then, the machine has been used in a mix of continuing development work and actual production operations intended to help the company advance towards that ambitious cost-reduction target.

As a production support tool, the robot is used in both a daytime mode alongside people and also in isolation at night. In the first of those roles it still operates autonomously tending a group of co-located additive machines within its 1.3m reach. In either case it can currently serve as many as 27 additive machines simultaneously.





Schwartz stressed that despite the "co-bot" tag, when operating alongside people the UR10 is not 'collaborative' in the strict sense that it is interacting with them, but it is exploiting the intrinsic capability that such machines possess to work in close proximity to them in complete safety without the need for any sort of protective enclosure. This, he said, is the result of the machine's low mass as well as payload and speed of movement compared to a high-end industrial counterpart, together with its inbuilt force-sensing capability that would bring it to an immediate halt if it did make any sort of inadvertent physical contact with a person.

Further development work is already under way to enhance both modes of operation. In the first case the company is working to add a machine vision capability to the robot which will, among other benefits, further increase safety of operation by making contact-sensing a proactive rather than







**01/02** The Eva co-bot developed in the UK by Automata

**03 / 04** the UR10 co-bot used by Voodoo Manufacturing

#### "Perhaps the most astounding figure is its cost, at just under £5,000"

reactive capability. It's also aiming to achieve what Schwartz admits is Voodoo's "ultimate goal" in its use of the machine: providing it with an autonomous degree of mobility – perhaps by mounting it on an automatic guided vehicle (AGV) or using a rail system – so that instead of being positioned statically within

an immediate group of additive machines, it could move among a more widely dispersed group.

He said that the company has calculated that when that goal has been achieved it should be feasible for the robot to serve "as many as a hundred" additive machines simultaneously.

Whichever way that goal is achieved, Schwartz said the fact that it is a realistic proposition underscores an essential characteristic of 'collaborative' robots – their "flexibility". He observed that it would simply not make sense to attempt anything similar with the sort of robot that is designed to be "deeply integrated into the manufacturing process for a single product". But, in contrast, "with our factory which is essentially digital and with a continually varying product line," then for the moment at least that flexibility wins out over sheer "performance".

That 'digital' element, by the way, is exemplified by the fact that despite the relatively low cost of all the hardware involved, Voodoo's factory is still essentially an example of Industry 4.0-type working. Schwartz explained that the robot is connected via an Ethernet link to a central server and from there to the internet, while the additive machines find their way to the internet via USB links to various servers on the shopfloor. Hence the internet is the integration mechanism for the robot and additive machines.

Right now, said Schwartz, the company is probably achieving "a 50 per cent utilisation" of its additive machines on a "24/7 basis". That should increase further with the projected addition of a second UR10 within the next six months. But that massive ultimate target may not be too far off either. Providing all goes to plan then he predicts it can be made a reality "within three to five years".

Could the entry price even for collaborative robots be set for a dramatic reduction? A small start-up UK company based in London claims it is set to do that through the introduction of a lightweight, six-axis collaborative robot with both enhanced ease-of-use and affordability compared to rival devices. Automata was set up by two architects, Suryansh Chandra and Mostafa ElSayed, after they found their own initial experience of the technology unsatisfactory – particularly what they saw as the irksome programming procedures they encountered.

The result of their work is 'Eva', a machine that weighs just 8kg, including its integral controller, so that it can be carried around by just a single individual and simply clamped to almost any available commonplace surface. Other key performance parameters are a 600mm reach and a maximum 1.25kg payload. But perhaps the most astounding figure is its cost, at just under £5,000, which makes a foray into robotics feasible for even the smallest manufacturing operation.

According to Chandra, a key enabling factor to achieving that low weight is that all parts of the machine are specifically designed for that particular application with no use of off-the-shelf componentry. In turn, that allows the weight of the heaviest single element – the motor – to be reduced accordingly.

Programming can even be effected over the internet. Chandra said that a laptop computer set up within Wi-Fi range of the robot can display a graphical representation of the device with programming carried out by straightforward keyboarding routines.

He explained that the control software is divided between the robot itself and a remote server, so that, despite its low cost, the machine can exploit state-of-the-art Industry 4.0 techniques for its programming, though if preferred programming can also be carried out by conventional 'move and memorise' procedures.

# Fusing old with new

# Firm bridging gap between additive and subtractive, writes Stuart Nathan

mall Heath has seen some changes over the decades. Its location on the main road linking Coventry and Birmingham made it a key site for industry; and until the early 1970s it was the home of BSA, churning out at various times rifles, handguns, bicycles, motorbikes, cars and taxis. Television viewers will know it as the home base of the fearsome *Peaky* Blinders gang, whose non-illegal interests include car

building and the metals trade, and a place where foundries belch smoke and flames. With changing times come changing fortunes, and much of the old BSA factory has been demolished. But part of the industrial heritage of Small Heath is now seeing a new phase for the manufacturing industry; a phase whose effects are still largely unknown.

The industrial CADCAM company Delcam began in Small Heath, and was established with a machine shop at its heart. Delcam was acquired by the American software company Autodesk in 2014, with many of its staff – and its machine shop – transferring to the new owners. Autodesk has invested heavily in the machine shop in recent years, and its official opening in mid-February revealed how the changing face of manufacturing technology is having a huge effect on companies whose direct involvement in production has traditionally been tangential.

The biggest change is, of course, the development of additive manufacturing as an additional route to producing finished products and components in place of, or in addition to, traditional subtractive processes like drilling, milling and grinding. Although the machinery to carry out these traditional processes has evolved considerably, they are still doing essentially the same thing as the very first machine tools developed during the Industrial Revolution, and these processes have contributed considerably to the form and function of many of the most fundamental machines we use today. "If you think of the gearbox, it looks the way it does because of how it's made," said Rob Sharman, head of additive manufacturing for GKN, one of Autodesk's biggest customers. "One of the big advantages of additive is that it allows you





to think of the job that a component like a gearbox does, and to design from first principles a mechanism to do that job. It might not look like a gearbox any more, but the freedom of being able to build components from scratch allows you to think in that completely novel way."

This isn't just relevant to end-users like GKN. Manufacturing machines, whether additive or subtractive, are driven by software and the increasing trend is for that software to be the same (or at least to be closely interfaced with) the software used to design the product or component being made. In what used to be the Delcam machine shop - and is now the Autodesk advanced technology centre - the extent of that convergence between design and manufacturing is becoming plain. In the technology centre, one machine is using traditional subtractive techniques to make uprights designed for the suspension of a Briggs Automotive sports car. Traditionally rather blocky and geometric components, the uprights emerging from the machine are more curved and organic-looking: generally, a tell-tale sign that they have been made by an additive process. Indeed, these were designed using a generative software tool often utilised in additive manufacture, that optimises material quantities in the areas of the component that have to endure the highest stresses; but along with these constraints, the system is also now taking into account the capabilities of the subtractive machine tool, coming up with a form that is a compromise between a "bird-bone"-like fully additive structure and a chunky traditionally machined component.

"The extreme of the highly organic-looking generative shapes is highly optimised but also, even when we constrain over subtractive machining, it takes a little bit longer to machine, said Andrew Anagnost, Autodesk's CEO, a typically informal Californian. "If we can start finding a middle ground between the old highly geometric way of doing things that use a lot of material and these highly organic shapes and move the two closer together, using the generative algorithm to kind of average between those two, we're going to get



AUTODESK.

**01** Steve Hobbs (left) and Andrew Anagnost (with scissors) open the technology centre

02 Autodesk is

modifying how machine tools work to best produce engineered components

#### "We are in our hearts an automation company"

Andrew Anagnost

even more practical solutions that can be deployed more broadly in more places." "We're looking at ways of making

technology more accessible to people who are, perhaps for good reasons, wanting to work with more conventional manufacturing technologies," added Steve Hobbs, a 30+ year Delcam veteran who is now Autodesk's vice-president for CAM and hybrid manufacturing. "Not everybody is ready to switch to powder bed additive as their main production technology, and for good reasons

– there is still some process development to go on there before it's suitable for making production-quality components in some cases."

Elsewhere in the technology centre, the bronze ship's propeller produced by wire arc additive manufacturing and recently certified for use in the Dutch port of Rotterdam on a tug (covered in January's edition of *The Engineer*) was was on display, along with demonstrations of automated grinding and polishing, using augmented reality to make plain to machine operators which areas of the component had been polished to the specified finish and which areas still have some way to go. Polishing is traditionally a hand process, and is a prime candidate for automation. Another demonstration machine was devising processes for milling automotive models from clay, and scanning any changes to models that have been made by hand to incorporate them into the design of the vehicle. One of the newest machines combines additive, subtractive and automated metrology to make repairs to a turbine blisk and ensure the repaired part is within tolerance.

Anagnost commented that Autodesk should not be thought of as a software company as much as a manufacturing process development and

automation company. "What used to be done with multiple disciplines and multiple deliverables being handed down back-and-forth is simply being taken over by interpretation by the computer; and that is inevitably going to evolve us into a design-make process company. That doesn't mean that we are a machine tool-making company at all – we are not – but we are going to be provider of streams of bits that feed highly automated factories in the future."

Autodesk's customers are organisations that manufacture, and buyers of machine tools. It may seem surprising that the research being carried out in the machine shop is not being done by the machine tool manufacturers themselves, but Autodesk's role is to help their customers get the best from their machine tools by using control software to modify the way they work. For example, it might be visibly obvious that the tool holder can move further, but some aspect of its operating system may be stopping it from exploiting the full range of its mechanism. In such a case, a machine manufacturer can allow Autodesk to "open the black box" and allow customised parameters to be set. One example of this could be seen in the machine shop where a large three-axis tool had been reprogrammed to act partially like a five-axis tool.

For Anagnost, this is all part of the trend of design moving closer to manufacturing. "We are in our hearts an automation company. The company was founded on automating doing drawings, and then ultimately, we automated the process of creating drawings from models. Now we're in the process of automating making something from a model," he said. This extends to products like Fusion Production, a system that helps manufacturers feed data back into their processes to improve performance; and to use information from environmental sensors to automate how workers can be warned of dangerous conditions such as dust levels, the presence of toxic gases or proximity of heavy moving objects. These might not be the same aspects of automation that other suppliers might consider, but they are no less important in operating a production environment, he argued. ■

# Bots with a grasp for retail

#### They'll pick, they'll deliver and even help you to shop, writes Helen Knight

warehouse technician takes out a component for a maintenance check. Without a word, his eager assistant immediately slides over to offer another pair of hands with the task. Unlike most assistants, this one never gets tired or has to nip off for a comfort break, because ARMAR-6 is a robot.

The prototype robot was recently delivered to Ocado Technology's robotics research lab, where the online grocer's team of engineers will experiment with the use of the technology in maintaining and repairing automation equipment.

The robot is the first prototype developed as part of the EU-funded SecondHands project, which is aiming to develop collaborative bots that can assist technicians working in Ocado's automated warehouses, known as customer fulfilment centres (CFCs).

More widely, ARMAR-6 is part of a growing robot workforce that is changing the way the retail industry operates, whether it is in the warehouse, on the road, or in the store.

At Ocado, for example, as well as designing a second pair of hands for the company's maintenance crew, roboticists are developing robots to pick and pack the 50,000 different items the grocer stocks.

The company has recently developed an articulated robot arm equipped with a suction cup and a 3D vision system that allows it to pick up thousands of different objects without damaging them, according to Graham Deacon, the robotics research team leader at Ocado Technology.

Rather than creating a model of each item to be picked, which would be extremely time-consuming, the engineers have developed a vision system that can identify the best grasp point on any object it sees. The system then lowers the articulated arm down into the crate where the suction cup, which is connected via a pipe to an air compressor, creates an airtight seal with the item's surface.

Sensors ensure the arm does not damage the item during picking, and the vision system then determines the right orientation to rotate it to, before placing it in the bag. "We are still in the process of quantifying how many different items the robot can pick up, but we expect it to be able to handle thousands of items," said Deacon.

Similarly, the team has been working on a soft-handed picking robot, capable of handling even delicate items such as fruit and vegetables without damaging them, as part of the EU-funded SoMA project. The project is investigating the use of a compliant gripper such as the RBO Hand 2, developed by the Technische Universität Berlin, which uses flexible rubber materials and pressurised air to passively adapt its grasp.

"If the robot is going to pick up a bunch of bananas, it will shape itself to the particular bunch it is picking up," said Deacon.

The robot's vision system is being designed to analyse the environment in which the object is placed, to determine if there is anything the gripper can use





**01** Ocado's SecondHands project at work in the warehouse

**02** Ocado's Andover CFC, where robots pick items from a 3D grid

**03** The Bossa Nova robot is being tested in Walmart stores





to help it pick up the item, such as the surface on which it is sitting, he said.

Ocado has invested heavily in robotics in recent years. Its fulfilment centres are highly automated, in particular its Andover and soon-to-be-opened Erith facilities, which are equipped with technology known as the Ocado Smart Platform (OSP). In the OSP, a swarm of robots pick items from a 3D grid, or hive, said Greg Hutton, head of construction and engineering.

"Our bots sit on rails and move left and right," said Hutton. "They can lower a gripper down to the box, which lifts it up into the belly of the bot, and then moves it into another position, or to a pick station or outlay point," he said.

Similarly, robots are now used to move shelves to the human pickers in a handful of Amazon's 16 UK fulfilment centres. The robots, called drives, slide under the shelves and move them around the facility as needed.

Outside its fulfilment centres, the online retailer is also developing the Prime Air service, which it hopes will ultimately see packages weighing up to 2.3kg delivered to customers by autonomous, GPS-guided drones, within 30 minutes or less.

The drones have been carrying out test deliveries to a small group of customers in Cambridgeshire in the UK, as part of a private trial, and the company hopes to widen their use soon.

Starship Technologies, meanwhile, is running trials of autonomous delivery robots on the streets of the UK, Germany and Switzerland. Working with German retailer Metro Group, as well as takeaway delivery company Just Eat and parcel service Hermes, Starship has deployed dozens of robots in five cities to run test deliveries.

The robots are designed to deliver groceries, food and packages to consumers within a two-three mile radius. The robots can drive autonomously,



"We're hoping to build robots that can help people in a shopping mall"

Oliver Lemon

while being monitored by human operators in a control centre.

Starship recently announced a partnership with Mercedes-Benz Vans to develop 'Robovan', a specially adapted van designed to carry eight autonomous delivery robots. The van will drive to a city or town and stop in a designated location, said Noel Sharkey, emeritus professor of artificial intelligence and robotics at the University of Sheffield.

"The idea is they will drive to the outskirts of a town or city, and then release all of the robots to deliver the goods," he said.

Last summer, Ocado also ran an autonomous delivery trial in south-east London, using a self-driving truck developed by Oxford's Oxbotica.

Robots are even finding their way on to the shopfloor itself. In the US, robotics firm Bossa Nova is testing autonomous service robots in 50 Walmart stores throughout the country. The robots travel up and down the aisles, taking images of the shelves and using AI to calculate the status of different products, including their location, price and any that are out of stock.

In Japan, SoftBank Robotics' Pepper robot is already being used by more than 2,000 companies, for tasks such as communicating with customers about services and products offered by the retailer, and guiding them around the store. Oliver Lemon, leader of the Interaction Lab research group at Heriot-Watt University, is experimenting with Pepper as part of the four-year, EU-funded MuMMER (MultiModal Mall Entertainment Robot) project involving SoftBank Robotics Europe.

The project, which also includes researchers from Glasgow University, VTT Technical Research Centre of Finland, LAAS-CNRS in France, and the Idiap Research Institute in Switzerland, is aiming to develop a humanoid robot, based on the Pepper platform, which can interact autonomously and naturally with shoppers within the unpredictable environment of a public mall.

"We're hoping to build robots that can help people find their way around a big shopping mall, or find products in the supermarket, while being entertaining and fun to use," said Lemon.

The researchers have been carrying out experiments, including a recent week-long stint in an Edinburgh supermarket, where they have been gathering data on how robots should best interact with people.

"These are things that as humans we don't even think about. You simply walk up towards someone and start talking, but there are lots of signals going on, such as eye gaze, body orientation and distance," said Lemon. "They seem mundane, but they're incredibly important to get right, because otherwise people might find it frightening if a robot drives towards them at high speed."

But if the move towards the greater use of robotics in retail continues at its current pace, we may all have to start getting used to robots driving up to us to deliver our groceries, or to point us in the direction of the chilled food aisle.

#### Advertisment feature

# Ocado Engineering: delivering innovation in grocery retail

For many consumers in the UK, ordering groceries online is now part of everyday life thanks to the delivery-based model pioneered by Ocado more than 15 years ago. Combining data, logistics and automation in a way the grocery industry had not seen before, Ocado quickly became the world's largest online-only supermarket.

At the core of the Ocado operational model sits centralized fulfilment, a concept where grocery orders are picked, packed and shipped to customers in one hour slots from a highly-automated facility called a Customer Fulfilment Centre (CFC).

Designing, delivering and sustaining the cutting-edge engineering and construction solutions to power these CFCs is Ocado Engineering, a division of the Ocado Group. In addition to underpinning the operations of Ocado.com, Ocado Engineering work on the automation fulfilment products that form an integral part of the Ocado Smart Platform (OSP), an end-to-end platform designed to power all aspects of a grocery e-commerce business. Recent adopters of OSP include Groupe Casino, a leading French retailer, and Sobeys, the second largest food retailer in Canada.

A typical OSP CFC includes two modular grids where thousands of robots work collaboratively across two temperature regimes (ambient and chilled) to assemble the items needed for a customer order in five minutes. In order to construct, fit-out and maintain these facilities, Ocado Engineering relies on three departments: Buildings Technology, Automation Engineering, and Engineering Operations.

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Buildings Technology own everything to do with the buildings and their systems, including their design, development, construction, upgrading and maintenance.

Automation Engineering are responsible for the end-to-end cycle of electro-mechanical automation. This covers the complete journey from creating the original concepts for bespoke automation equipment; to making sure these designs work with the framework and are incorporated in such a way that they can run as efficiently as possible; to implementation planning and sourcing appropriate suppliers; and finally to incorporating these designs within CFCs at millimetre precision. The OSP robots and related systems, alongside all the other OSP software modules, are designed in-house by Ocado Technology and Ocado Engineering.

Finally, Engineering Operations continually monitor and maintain the automated mechanical handling equipment to ensure that the thousands of time-sensitive orders a CFC processes and delivers each day fulfill their one-hour slot commitment. These three departments also work together seamlessly to make sure that there is continual cross-departmental feedback, allowing them to constantly improve upon their solutions. More information about Ocado Engineering can be found at :

www.ocadoengineering.com

#### **DID YOU KNOW?**

- Ocado Engineering includes more than 300 people, including technicians, engineers and project managers
- The OSP CFC robots reach speeds of 4m/s and rely on the world's densest 4G network to communicate
- The CFC in Andover, Hampshire used more steel than the arch over Wembley Stadium and enough aluminium to make 70 million soda cans
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# New confidence on the Shelf

An upswing in the oil price has brought renewed optimism to the North Sea, along with a wave of fresh recruitment initiatives. David Fowler reports **01** Morecambe Bay Central Platform

**02** Spirit Energy, Barrow

dramatic drop in the price of oil, from \$115/barrel in June 2014 to a low of less than \$30/barrel in early 2016, had serious consequences for the UK offshore oil and gas industry. Exploration and development of wells, investment and jobs were all badly hit.

With the recovery of the price of Brent Crude last year, on the way to over \$70/barrel in January and the current price of around \$65/barrel, and following successful efforts to bring production costs down, there are signs of renewed confidence.

In its outlook for the sector last year, trade body Oil & Gas UK said "the upturn in oil price has coincided with signs of confidence returning to the basin" and noted "within two years, the sector has halved its average unit operating costs".

At the end of January, BP announced two new discoveries: Capercaillie in the central North Sea, and Achmelvich, west of Shetland, and hopes to double its North Sea production. Its Clair Ridge field is due to come into production this year.

Also last month Shell approved plans to develop the Penguins field north of Shetland, authorising the construction of a floating production, storage and offloading vessel, the first new manned installation for Shell in the northern North Sea in almost 30 years. The development is expected to have a break-even price below \$40/barrel.

And Spirit Energy, the exploration and production joint venture formed last year by Centrica and Bayerngas Norge of Germany, announced that it will drill a new well at the Chiswick field in the southern North Sea to bring around a further 50 billion cubic feet of gas on stream in a £75m investment.

What does this mean for skills and recruitment? Though the oil and gas industry's workforce shrank from 450,000 in 2014 to 330,000 in 2016, Oil & Gas UK said in its annual report that "the largest reductions may be behind us". Some smaller companies in the supply chain, often driven by technological innovation, were increasing their headcount.

Simon Bartington, a director at recruitment agency CBS Butler 360, with over 20 years' experience in the offshore industry, says that 2014's downturn "put the brakes on recruitment and investment overnight. The industry drew in its horns and looked at assets and its return on investment".

The downturn had one positive effect, however. The industry looked closely at cost-reduction measures. This included "quite a bit of investment in software systems and advanced process control", said Bartington, and this helped to make small but cumulatively significant increases in yields ."Costs have been reduced quite



considerably," he said. "When the price started to bounce back, companies found they were now making quite a decent profit."

"Now that the oil price has passed the threshold of \$50/barrel," he added, "exploration is starting again. We're seeing a lot of pressure now to get production up and running."

The numbers employed in the North Sea are set to rise, he anticipates. Today's installations do not require the same level of personnel to operate them as in the past, "but there is going to be an increase in the North Sea sector".

Spirit Energy HR director Dean Marks said: "I think everyone from the sector will agree that the oil price rising above \$60 is a good thing." But he added: "What we all want is stability: when we look at projects which are five, ten or 15 years in maturation, stability is a key aspect."

Though UK oil and gas had suffered a few years of low prices and shedding jobs, he said, "I believe the industry can offer exciting opportunities for a whole range of disciplines", from engineering to geologists and geophysicists, and the technical and business functions that support them.

CBS Butler's Bartington said that over two decades there had been a change in the balance of skills required by the industry. Skills now being sought are more biased towards control and instrumentation, automation and process control. "Given a lot of the technology now available, fields in the North Sea can be managed remotely from Houston," he said. Skills in IT and telecommunications are also soughtafter: with installations increasingly





being networked, cybersecurity to protect operations from disruption is becoming vitally important.

Spirit Energy's Marks said the company would continue to seek to recruit graduates in mechanical, process/chemical and electrical/ control and instrumentation engineering, and apprentices in mechanical, electrical and control and instrumentation. Last year, the company took on four apprentices, two men and two women - numbers are limited to make sure Spirit can provide them with the experience that they require to develop successfully, Marks said. A broadly similar number is expected to be taken on this year.

Spirit is in the process of assessing its graduate needs and developing its own graduate programme, having previously participated in Centrica's graduate scheme. The company recently sought applicants via the Gradcracker website for summer engineering placements from students about to go into their final year. Many of these go on to join the company's graduate programme.

It has an active policy of engaging young people, with employees visiting schools to promote and raise awareness of the opportunities of a career in science and technology. "Spirit is very keen on starting at the school leaver and apprentice level to encourage women and men to consider coming into the oil and gas industry," Marks said.

He added that the organisation, led by chief executive Chris Cox, "is driving the fact that opportunities in Spirit are open to all regardless of gender, race and religion". Diversity is also supported by an employee-led organisation, the Network, which is open to all Spirit

#### "A lot of the skills that exist in different industries are fully transferable to the oil and gas industry"

#### Spirit Energy's Dean Marks

Energy employees and focuses on tackling inclusion issues. He said the company is seeking to increase the awareness in other industries of what the oil and gas industry can offer. "A lot of the skills that exist in different industries are fully transferable to the oil and gas industry – [we want them to] have a look at what we can offer, see what you can be involved in."

John McDonald, chief executive of industry training body OPITO, admitted that the perception of the sector and whether it still offered career longevity had "taken a serious knock over the past few years, especially in energy hub areas such as Aberdeen and Norfolk".

However, he stressed that the Oil & Gas Technical

Apprentice Programme (OGTAP), co-managed by OPITO and the Engineering Construction Industry Training Board, "remains one of the UK's most successful apprenticeship initiatives", with over 1,500 young people coming through its ranks since its inception 20 years ago. He said: "There are many other types of modern apprenticeships that could also benefit our industry, particularly as we experience further diversification." However, the government's apprenticeship levy introduced last year "is proving to be a deterrent to employers".

Attracting women into the sector remains a difficulty. OPITO recently held two successful Girls in OGTAP evenings to encourage more young women to consider the sector and to try to dispel some of the myths that may be holding them back, where they were able to meet current female OGTAP technicians and other female industry professionals to hear first-hand about working offshore.

McDonald said: "The industry has undergone significant changes over the past few years, including the increased use of new technologies and data-driven processes." This would affect the skills required by the next generation. A future challenge to job security could emerge depending on how new areas of automation and artificial intelligence developed and potentially changed roles in the industry as the so-called fourth industrial revolution took hold. "This digitisation movement has already begun," he said.

As part of the industry's response, OPITO launched a UK Continental Shelf skills study at the end of last year, with research being undertaken by Robert Gordon University in Aberdeen. "This in-depth labour-market intelligence analysis will determine the conditions of the sector and support a new skills strategy for the continued success of the UKCS over the next 20 years," said McDonald. The report is due to be published in May. ■



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#### Both Tekna and Emmegi machines on stand H7-350 at MACH. Sponsor: Emmegi (UK)

Emmegi (UK) is part of one of the world's leading manufacturers of systems for machining aluminium, PVC, and steel. The Emmegi group also includes Tekna and Keraglass, giving buyers access to the widest choice of machine options from one UK based specialist.

At MACH, much of the focus on the Emmegi stand will be on the Tekna 944 CNC machining centre – a truly flexible, heavy duty option with a mobile gantry.

This 4-axis machine, designed for drilling, milling and threading on aluminium or steel sections, features a high torque electro spindle. This moves along the A axis, machining on three faces through a full 180°. A clamp unit ensures the correct positioning of sections, and counterblocks can be mounted quickly and accurately to make the machine extremely versatile.

The Tekna 944-4 comes with a choice of four or 12-piece tool magazine and is compatible with a Renishaw probe. At MACH, it will be on display in a 4m size, but is also available in a 7m version for larger scale applications.



have a range of precision cutting saws on its MACH stand, with options to suit any size of manufacturing operation. These will include everything from an automatic saw with NC bar feeder to a manual single head chop saw.

#### **Riveting and drilling in one step GESIPA® FDR®** Sponsor: GESIPA®

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

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

This technology provides many solutions for the joining of different



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

#### Next-generation smart sensors put ease-of-use first

#### **'BluePilot' alignment leads radical upgrade** Sponsor: SICK UK



SICK's next-generation W16 and W26 smart sensors with "BluePilot" alignment are at the helm of a streamlined portfolio of photoelectric sensors, radically-upgraded to optimise ease-of-use with complete object detection reliability.

The W16 and W26 proximity, reflex and through-beam sensors are manufactured at a purpose-built, fully-automated production facility in southern Germany. They mark the culmination of a two-year, €multi-million research and development project involving extensive consultation with SICK customers worldwide. For usability, the W16 and W26 sensors are launched with SICK's new BluePilot assistant, which features a line of five LEDs mounted on top of the sensor for quick, easy and accurate alignment of the light spot even over long distances.

SICK W16 and W26 sensors bring together the best of SICK's optical sensing technologies including Twin-Eye for detection of reflective materials; LineSpot linear optics where the object has mesh, perforations, integral gaps or breaks and ClearSens optical filter technology for detection of semi-transparent and transparent objects.

The sensors are immune to interference from unwanted light sources and reflections, including LED lighting, hi-viz safety workwear or reflections. SICK's AutoAdapt function means if the reflector or the front screen of the sensor becomes contaminated, the photoelectric sensor automatically adjusts its switching thresholds for reliable detection.

An industry-first in-built Bluetooth option allows easy monitoring and advanced commissioning from smart phones or tablets.

# March 1957

# Magic roundabout

#### Fairground matters took The Engineer readers on a ride

he world's tallest big wheel can be found in Las Vegas where the High Roller stands at a height of 168m and has been entertaining the public since March 2014.

This achievement would no doubt have enthralled PW Bradley, a funfair enthusiast who contributed 'Further notes on the development of fairground machinery' in the 22 March 1957 edition of The Engineer.

Bradley had already contributed to this journal on fairground matters and reappeared to focus on big wheels, the development of which goes back as far as 1620, a fact brought to readers' attention by way of historical waypoint and technological baseline.

Alerting readers to Volume 1 of The Travels of Peter Mundy in Europe and Asia, Bradley recalled a journey that took Mundy to a fair in Philippopolis, southern Bulgaria, where three kinds of amusement were observed: two being crude versions of the roundabout and swing, and the third "like a crane wheel at the Custom House Quay and turned in that manner, whereon children sit on little seats hung round about in several parts thereof, and though it turns right up and down, and that the children are sometimes on the upper part of the wheel and sometimes on the lower, yet they always sit upright".

For Bradley, the big wheel was a roundabout with a horizontal axis that would gradually become a fixed feature in amusement parks.

"In the middle 'thirties, smaller wheels of American design, with up to sixteen two-seater cars and of all-metal construction, began to appear in our coastal amusement parks. Later, in the immediate post-war period, the smaller of these (the twelve-car version) became popular as a travelling proposition... several operators have eased the moving operation by semi-permanently building the base frame and the lower parts of

#### THE ENGINEER

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THE ENGLACES

Further Notes on the Development of Fairground Machinery

the standards on a heavy road wagon." This portability was an important development and, in August 1956, the UK was introduced to what Bradley called "a new Big Wheel era for fairgrounds". He reported that the ride was brought from France and erected for the last few weeks of the Battersea Park fun fair season. It consisted of a big wheel mounted on a large roller-bearing turntable and Bradley noted that "the resultant of the two continuous rotations is quite unlike the motion of any known previous amusement machine in being spherical".

"The device therefore represents a definite advance in fairground engineering design," wrote Bradley. "In accordance with modern practice, welded tubular construction is extensively employed, and other components are of pressed steel. Timber is utilised only in the circular loading platform and steps. The example seen in Battersea Park has fourteen cars, each seating four persons. The diameter of the wheel is about 50ft and its axis is about 36ft above ground level.

#### Bradley discussed the history and design features of big wheels through the ages

The diameter of the base turntable also is about 36ft."

Bradley further observed that in previous big wheel practice, each bearing of the axle had been mounted on an upright column which withstood the entire vertical load, and was stayed by three comparatively light inclined members, which are constituent pieces of a complex structure, especially in load-bearing structures.

"Such an arrangement, if used in this new machine. would have demanded a second set of rollers running on a circular track," he said. "These rollers and their track being

capable of carrying the weight of the wheel and standards concentrated at two points."

This arrangement, wrote Bradley, had been avoided by eliminating vertical standards altogether; instead, the axle was supported by four inclined members with their feet pin-jointed to four of the roller plate assemblies.

"The structure is rendered completely rigid by two members (which locate the feet of the main legs and obviate undue stress on the links), and a pair of inclined stays having their feet pinned to the two remaining roller plate assemblies," he added. "The wheel is turned about its horizontal axis by normal 'Big Wheel' driving gear; an endless cable passing round deep-grooved carriers on the spokes, the driving pulley and a tensioning pulley."

The wheel's 14 cars were designed to resemble flying saucers, "as a concession to present-day imaginative taste". Suspended so as to remain upright, Bradley observed that they were fundamentally no different to those seen by Mundy over 300 years previously. JF

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#### Word oftheissue

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

The screw fastener holds a unique position in any engineering project. It plays its only functional role at the assembly stage, but without it the whole thing falls apart. Yet there is an element which plays no role after the assembly – except during maintenance or repair – and that is the means by which the fastener is tightened. Originally screws were provided with slots but latterly with a better means of applying torque. All are referred to as a recess.

Etymologically this comes from the Latin recessus meaning 'going back, retreat' and derived from recessum and ultimately recedere 'to go back, withdraw, depart, retire'. Splitting this last root word into its composite elements, we find re 'back' and cedere 'to go', the former having examples in many languages, the latter derived from Proto-Indo-European ked 'to go, yield'.

The modern use of 'recess', for a break or rest period, is first seen in the 17th century, from recessing to private chambers.

# Bigpicture



The opening ceremony of the Olympic Winter Games PyeongChang 2018 was lit up with a record-breaking drone light show. Intel broke the Guinness World Record for 'most unmanned aerial vehicles airborne simultaneously' when it sent 1,218 Shooting Star drones into the sky to mark the start of the games.



#### Prizecrossword

When completed rearrange the highlighted squares to spell out a brick which has been unequally fired. The first correct answer received will win a £20 Amazon voucher. Email your answer to **jon.excell@centaur.co.uk** 

#### Across

- 1 Near to (6)
- 4 Cause to burst (8)
- 10 Toady or lackey (9)
- 11 Movable barriers in a fence or wall (5)12 Device producing intense narrow
- beam (5)
- 13 A communal dining-hall (9)
- 14 Remaining stationary (7,2,5)18 Restorations back to an original state (14)
- 20 A numerical average (4,5)
- 22 Sign of the zodiac (5)
- 24 Deposits of valuable ore occurring
- within definite boundaries (5)
- 25 Having eight sides (9)
- 26 Removing by cutting off (8)
- 27 Carves out into a block (6)

#### Down

- 1 Ancient brass cannon (8)
- 2 Terminates the employment of (5)
- **3** Gerard, the French film actor (9)
- 5 In beyond one's knowledge (3,2,4,5)
- 6 A system of reasoning (5)
- 7 Small container for fuel (6,3)
- 8 Interpretive literary compositions (6)
- 9 Tethered wartime airship (7,7)
- **15** Held section of a chopping tool (3,6)
- 16 Artificial illumination (9)
  - **17** Attacks someone physically or emotionally (8)
  - 19 Extracts by heating (6)
  - 21 Protective eyepiece on helmet (5)
  - 23 Strong worktable (5)

February's highlighted solution was cadmium. Winner: Tony Weeden

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