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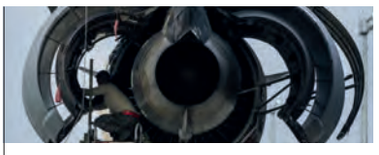

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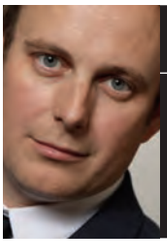

our**opinion**

A grain of truth

Regular online readers may have been tickled by *The Engineer's* April Fool's offering earlier this year: the 'fake' news that the US president has enlisted an army of 3D-printing robots to build his controversial border wall.

The scenario we presented, complete with autonomous drones designed to replenish the robots' powdered-gold feedstock, was obviously ridiculous – although we did receive a message from someone called 'Donald' congratulating us on our idea. But as with all half-decent spoof stories there was the tiniest grain of truth to our flight of fancy.

In recent years, *The Engineer* has reported on a host of initiatives aimed at freeing 3D-printing techniques from the constrained confines of the metal box, primarily with a view to either building or repairing structures too large or inaccessible to fit in an additive machine. And in this issue's cover story (p22), we examine this trend in more detail.

In particular, we look at how the integration of additive and robotic techniques – a long-standing area of R&D in the sector – is beginning to find its way into the commercial mainstream. And while the 3D-printing robots of our seasonal spoof might be a long way from reality, it's clear that 'out-of-the-box' additive will be an interesting trend to watch in the years to come.

> "The integration of additive and robotic techniques is beginning to find its way into the mainstream"

Additive is something of a recurring theme throughout this issue. In our special Advanced Manufacturing supplement (p44) we take an in-depth look at Stratasys' new continuous build demonstrator, a concept multi-cell 3D-printing system that points the way towards how additive techniques might be adapted for mass manufacturing. Meanwhile, in a fascinating article on one of additive's most challenging application areas, ESA's Dr Johannes Gumpinger (p48) looks at the numerous ways in which the space sector is looking to use the technology: both here on Earth, up in orbit, and ultimately to build habitations on far-off planets. And if that's the end game, then perhaps a 3D-printed wall isn't quite so ridiculous after all!

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AUTOMOTIVE

Driverless takes to the open road

On-demand service will start in France later this year

HELEN KNIGHT REPORTS

Europe's first on-demand driverless vehicle service on open roads is to begin operating in France later this year.

The pilot service, a collaboration between Delphi and French-based public transport operator Transdev, will see autonomous vehicles operating in Saclay, a Paris suburb, and Rouen in Normandy.

In Paris, one shuttle will initially operate along a fixed route from the train station to the campus of the University of Paris-Saclay.

The Rouen service will operate in an area of the city where there is currently no public transport, and will initially consist of two driverless Renault Zoe cars.

Customers will be able to use a smartphone app to book a ride in the vehicles, which will be tracked by a remote control-and-command centre. A driver will initially sit in on the journeys to monitor the vehicles. By 2018 the companies hope to operate the service without a driver on board.

For the pilot, the companies have chosen the so-called 'last mile' of public transport – the journey between a train or bus station and the commuter's place of work, for example – as it is seen as an area of particular need, according to Serge Lambermont, director of automated driving at Delphi.

"People like to travel by public transport, but this last mile, how to get from your subway station to your destination, is an inconvenience," he said. "So if you can arrive with the ticket already on your smart phone connecting you to an automated, mobility-on-demand taxi or pod system, which takes you on to your location, you take all the inconvenience out."

The vehicles will be equipped with a range of different sensors, designed to complement each other. Each vehicle will be fitted with short-range radar, for example, with sensors at each corner and two at either side, as well as one forward-facing image radar and one rear-facing long-range radar.

Radar can detect large objects in the vehicle's path and can determine that object's distance and oncoming speed. It can also work in all weathers, and at night.

The vehicles are also equipped with six cameras, including one high-resolution camera, as well as one rear-facing, two blind-side, and two corner-facing. Unlike radar, cameras can detect colour and use this to help distinguish between different objects, such as traffic lights and tail lights.

The vehicles will also be fitted with LIDAR (light detection and ranging) sensors, which operate by sending out pulses of light and interpreting the light that is reflected back.

A centralised computing platform will host all of the processing required for the autonomous driving system, including Delphi's Ottomatika vehicle control algorithms. Information from the sensors, plus mapping and navigation data, is amalgamated to make driving decisions.

The software also allows each vehicle to communicate with the cloud, so that ultimately anything they learn through driving can be shared among the fleet, said Lambermont.

"Humans learn to drive through experiences such as near-misses, and if such an event were to occur on the automated driving system, we would like to send it up to the cloud and broadcast it to all the vehicles," he said. "We are not quite there yet but that is really the power [of the technology], you only need to learn something once and then you can broadcast it [to the fleet]."

Delphi has also been running autonomous vehicle technology in Singapore.

The pilot service is a collaboration between Delphi and Transdev

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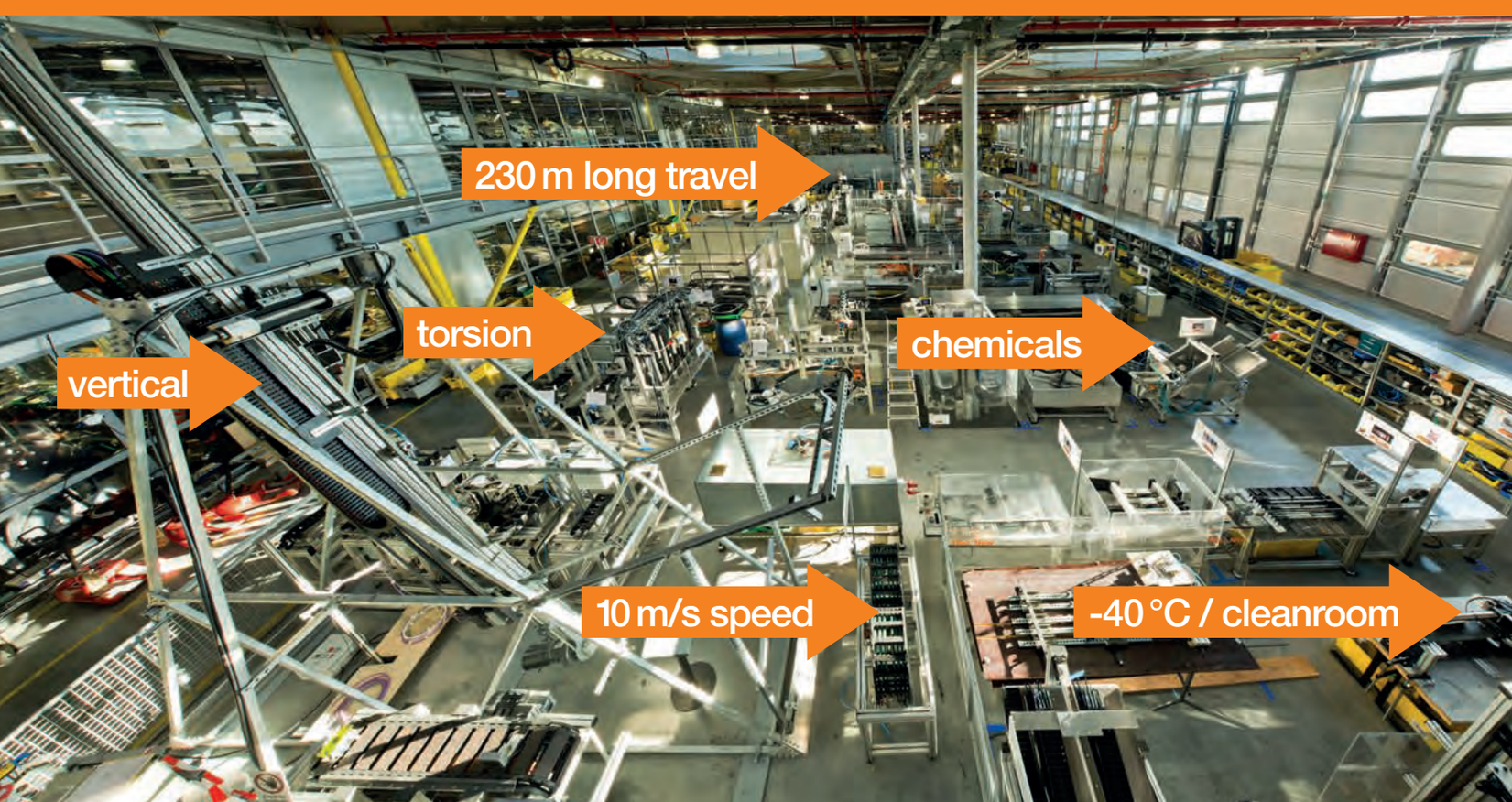

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STRUCTURAL

Blaze puts utilities in the spotlight

Fire detection and utilities to be revisited after Grenfell tower block tragedy

JASON FORD REPORTS

Standards for multi-occupancy dwellings could be modified

Standards related to the connection of utility supplies and fire detection systems are likely to be revisited following a catastrophic fire at a residential tower block in London.

Forty fire engines and over 200 firefighters and officers were called to the Grenfell tower block in North Kensington at 0054 on 14 June 2017 to tackle a blaze that engulfed the 24-storey building.

Built in the 1970s, the Grenfell tower block had undertaken a £10m refurbishment that saw the bottom four floors remodelled to create nine new homes, plus the addition of rain-screen cladding, replacement windows and curtain wall façades. Internally, a new communal heating system and smoke extract and ventilation system were fitted.

Mark Coles, head of technical regulations at the Institution of Engineering and Technology (IET), explained that refurbishment in a multi-occupancy dwelling could involve modifications to the delivery of utilities such as electricity, gas and water.

This can require the routing of pipes and cables through different sections of a building, and that these penetrations can breach 'what is deemed to be the fire compartment'.

"Where you need to take cables and pipes… in and out of these buildings [then] you need to penetrate the walls. You can't get around this because you need to take services in and out," he said.

"You need to make that penetration as impervious to fire as it was prior to that penetration being cut. The way you do that is with fire seals. If there's a rise in temperature these seals expand and block up all the gaps to stop the spread of smoke and fire. That's what's meant to happen."

Coles added that another aspect of investigation might focus on consumer units – fuse boxes – that from 2015 have had to be made from non-combustible materials instead of plastic.

"In 2005, London Fire Brigade were experiencing around 30 fires a year in this particular area," he said. "In 2015 it had gone up to about 300, and this was put down to poor connections within the consumer unit and with it being made of plastic, which is fuel to the fire."

According to the BBC, residents reported escaping the blaze after being woken by neighbours fleeing the building via a single staircase. Coles said that within BS 5839 Part 1 there are requirements to test the smoke detectors, heat detectors and manual alarm call points at least weekly as part of the ongoing maintenance regime.

The Grenfell Action Group said on its website that it had predicted the Grenfell catastrophe, adding that it was "inevitable and just a matter of time".

PAY

Survey points to shortfall in female pay

Overall gap between men and women is unchanged

JON EXCELL REPORTS

Women engineers earn on average £10,000 less per year than their male colleagues according to *The Engineer*'s 2017 salary survey.

The survey is based on responses from 2,743 UK engineers working across a range of different sectors, seven per cent of which are female.

The average salary for female respondents to survey is £38,109. This compares to £48,866 for men, and an industry average of £48,000.

Although the figure represents a slight increase on the average salary among women in 2016, of £36,201, the overall gap in salaries between men and women remains unchanged, and it seems that female engineers have benefitted less from an industry-wide average salary increase of 6.6 per cent over the past 12 months.

Perhaps most concerningly, women at every level of seniority are on average paid less than their male colleagues. For example, at junior level women earn on average £4,000 less than their male colleagues. The gap widens at director level with women paid on average £20,000 less.

The best-performing sectors in terms of gender diversity are academia and the rail, civil and structural sectors, where just over 10 per cent of respondents are female. The biggest gender gap was found in automotive, where women accounted for just 2.8 per cent of the sample.

Helen Wollaston, CEO of WISE (Women in Science & Engineering) told *The Engineer* that she expects gender pay gap reporting – which is due to come into force next April – to help address this issue.

Newsinbrief

Boeing on the rise

Boeing's forecast for new aircraft has risen with a projected requirement for 41,030 new aircraft worth $6.1trn over the next 20 years. According to Boeing, the single-aisle segment will see the most growth over the forecast period, which will be fuelled by low-cost carriers and emerging markets. A total of 29,530 new aircraft will be needed in this segment, representing an increase of almost five per cent.

New train time

Bombardier Transportation has been awarded £895m to supply and maintain 750 Aventra trains for the FirstGroup/MTR partnership, which takes over the South Western franchise in August 2017. The new trains – supplied in five-car and 10-car configurations – will operate on suburban routes serving Windsor, Reading and west London. The new trains will come into service from mid-2019 and will be in place by December 2020.

Sustainable sector

UK Automotive's 18th annual Sustainability Report shows that the manufacturing sector turned over £77.5bn in 2016, while productivity, production output and vehicle sales also increased. The industry improved its environmental impact, with waste to landfill falling to a new low of 0.9 per cent of all waste produced.

Heat source

Energy projects investigating smart heating systems and the application of hydrogen as a potential heat source have received £35m from the BEIS Energy Innovation Programme. £10m will sponsor the second phase of work by the Energy Systems Catapult on its Smart Systems and Heat Programme.

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ENVIRONMENTAL

Safety first for drinking water

Technology allows remote communities to test their water supply

HELEN KNIGHT REPORTS

More than 1.5 million children under five years old are estimated to die each year from diarrhoeal diseases caused by unsafe drinking water and poor sanitation.

But providing clean, safe water to remote communities in the developing world remains a challenge, as there is often not the infrastructure in place to deliver it.

To reduce rates of diarrhoeal disease in remote communities, researchers at York University are developing monitoring technologies to allow local people to test the quality of their water supplies.

At any one time, approximately 1.8bn people are accessing contaminated water, according to project leader Dr Steven Johnson.

"If we build a centre that the community could use, which would allow them to test the quality of their water, they could then decide whether to drink that water [as it is], access water from a different source, or to treat the water," said Johnson.

The researchers are working with Oxfam and communities in Vanuatu, a collection of 80 islands in the South Pacific, which is known as the most disaster-prone country in the world. Following Tropical Cyclone Pam in March 2015, for example, half of the population went without clean drinking water for one month after two-thirds of water and sanitation infrastructure was destroyed.

The technology will be developed with the local community, in a process the researchers have dubbed Integrated Participatory Technology Development, to ensure the resulting systems meet the needs, skills and environment of those living locally.

The co-development team will focus on two types of sensing technology, as part of the project, which is being funded by the EPSRC through the Global Challenges Research Fund.

The presence of faecal coliform bacteria is typically detected by taking samples of water and growing any bacteria present on a plate, which can then be examined under a microscope.

"Rather than using an expensive microscope, we hope to use optical components similar to those inside a CD-ROM drive, and combine it with some image processing, to automatically identify faecal coliform bacteria," said Johnson.

At any one time, 1.8bn people are accessing contaminated water

AEROSPACE

Helicopters are looking forward

Aircraft is equipped with forward-facing propellers

Airbus has demonstrated the latest phase in its development of Racer, a concept claimed to represent a step-change in the performance of helicopters.

Racer (Rapid And Cost-Effective Rotorcraft) is being developed through the EU's CleanSky initiative and is being designed to achieve the optimum trade-off between speed, cost-efficiency, sustainability and mission performance.

Rather than generating thrust from the main rotor by twisting the blades of the propeller along their axes to change their angle of attack to the air, the aircraft is equipped with two forward-facing propellers placed at the end of short forward-angled wings that sit on top of the aircraft cabin and underneath the main rotor.

The 'box-wing' structure enables a number of benefits; including improved lift performance in forward flight, and the incorporation of so-called 'pusher' propellers on the lower wing. **JE**

MATERIALS

Getting a grip on pollutants at the micro scale

Biomaterial wins scientific award

HELEN KNIGHT REPORTS

A biomaterial capable of removing micro-pollutants such as pesticides and pharmaceuticals from waste water has won a science award.

Micro-pollutants, including high-performance chemicals and heavy metals, only make up a small proportion of overall pollution but can be extremely difficult to deal with using existing treatment processes, rendering freshwater unusable.

The new granular adsorbent, developed by Imperial College London spin-out CustoMem, is capable of binding and removing a range of micro-pollutants, including perfluorinated compounds.

These pollutants, which are highly toxic to both humans and animals, are used in aqueous film forming foams used for fire fighting, and can also be found in fluoropolymer-coated cookware and sports clothing.

The adsorbent, known as CustoMem Granular Media, is a nanocellulose-based material, said Shayne Petkiewicz, business development manager at CustoMem.

The material can selectively capture micropollutants 10 times faster than traditional adsorbent materials such as anion-exchange media, he said.

"We have used our biomaterials and synthetic biology skills to introduce new properties, both at the micro and macro level, which allow us to do things that other media can't do quite as well," said Petkiewicz. "So we have been able to increase the surface area, and we have also changed the surface chemistry so that it can target compounds of choice," he said.

The material has been awarded the £25,000 Venture Prize by the Armourers and Brasiers Company.

The material has won a £25,000 prize

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AUTOMOTIVE

Car emissions are an issue of reform

Catalyst-based reformer could contribute to emissions reduction

HELEN KNIGHT REPORTS

An on-board reformer capable of converting exhaust gas into fuel and removing pollutants could help carmakers to achieve tough emissions targets.

The fuel efficiency of modern cars has improved by 20 per cent since 2010, as a result of improvements to engine design, weight reductions, and the use of hybrid technologies.

But while these improvements have enabled manufacturers to meet their 2015 targets for reducing carbon-dioxide emissions, car makers are still 15 to 30 per cent short of their 2020-21 target of 95g per km, according to Dr Athanasios Tsolakis at Birmingham University.

> "It produces a hydrogen-rich gas for combustion in the engine"
>
> Dr Athanasios Tsolakis

To help meet this target, Tsolakis and his colleagues are developing a catalyst-based reformer capable of improving the fuel economy and therefore reducing greenhouse gas emissions of petrol engines.

"The system uses the engine exhaust gas, consisting of heat, water, CO_2 and in some cases O_2, and fuel to produce a hydrogen-rich gas that is then used for combustion in the engine," he said.

The EPSRC-funded project, which also includes researchers at Brunel University, as well as Ford and Johnson Matthey, will use platinum/rhodium (Pt-Rh)-based catalysts to produce the hydrogen-rich gas, which can then be used for combustion.

"This means that the engine fuel – gasoline and hydrogen-rich gas – has a higher energy content," he said.

It should also reduce engine pumping losses by allowing for a better throttle position, said Tsolakis.

The technology can also be designed to reduce emissions from diesel engines, he said. It can also indirectly improve diesel engine fuel efficiency by improving the performance of after-treatment systems. Existing after-treatment systems can use large quantities of fuel to remove pollutants from the exhaust, but the new reformer would need only a few parts per million of hydrogen to operate, said Tsolakis.

In the first stage of the project, the fuel reformer will be integrated into the exhaust, to provide small quantities of hydrogen-rich gas to the engine's after-treatment system, when needed.

The researchers plan to develop a compact catalyst brick, designed using additive manufacturing techniques, which can be integrated into the after-treatment system in both diesel and lean combustion petrol engines.

The fuel efficiency of modern cars has improved by 20 per cent since 2010

MARINE

Remote-controlled manoeuvres

Vessel demonstrated in Copenhagen harbour

The world's first remotely operated commercial vessel has been demonstrated by Rolls-Royce and towage operator Svitzer in Copenhagen harbour.

Svitzer's 28m-long Svitzer Hermod undertook a number of remotely controlled manoeuvres earlier in 2017. From the quayside in Copenhagen harbour the vessel's captain, stationed at its remote base at Svitzer headquarters, berthed the vessel alongside the quay, undocked, turned 360°, and piloted it to the Svitzer headquarters, before docking again.

The companies will continue to test remote and autonomous operations for vessels with primary systems made up of autonomous navigation, situational awareness, remote-control centre and communication.

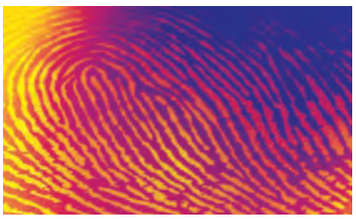
Built to a Robert Allan ship design, the Svitzer Hermod is equipped with a Rolls-Royce Dynamic Positioning System. **JF**

SECURITY

Infrared eyes at the scene of the crime

Method could help to embellish fingerprints

STUART NATHAN REPORTS



The ablation can vapourise water

Fingerprints can identify people present at a crime scene, but these marks can hold more information than just the identity of the person who made them.

Residues of any substances the person had been in contact with can also be transferred to surfaces they touch – but recovering and identifying those substances can be very difficult.

Researchers from Louisiana State University in Baton Rouge have now devised a method that could help with this problem.

Inspired by team member Eden Camp's time interring with the Louisiana State Police Crime Lab, Prof Kermit Murray and postdoctorate student Fabrizio Donnarumma applied their expertise in using infrared lasers to lift minute layers of tissues for bioanalysis to the problem.

In a paper in the *Journal of The American Society of Mass Spectrometry*, Murray's team describes how it found it could use its laser equipment to ablate away fingermarks from a surface, suck the resulting vapour into a thimble-sized filter system and then subject these captured materials to techniques such as gas chromatography or mass spectroscopy to identify what substances were present.

The ablation works by rapidly and specifically vapourising any water in the fingermark, carrying any other trapped material off the surface.

"We realised that if our techniques work for biomolecules as fragile as DNA and RNA, it should work with almost anything," said Donnarumma. "We can capture almost anything that is on a surface. In this case, it just happened to be fingermarks."

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MEDICAL

Speeding up breast cancer diagnosis

Photoacoustic system could cut stages of tumour detection

HELEN KNIGHT REPORTS

The time taken to receive a breast cancer diagnosis could be significantly reduced, thanks to an imaging system designed to cut the various stages of tumour detection down to a single scan.

Breast cancer diagnosis can take a number of weeks, involving a visit to the GP, an x-ray mammogram and an ultrasound or even an MRI, before a patient undergoes a biopsy.

The new photoacoustic system is being developed by researchers at the University of Twente in the Netherlands.

The patient lies face down on a bed, placing their breast into a hemispherical bowl lined with up to 100 optical fibres, and several ultrasound detectors.

Multiple images are taken from different angles. These are then assembled into a single 3D image, according to Srirang Manohar, the project coordinator.

"The imager will be non-invasive, will not require contrast agents nor use ionising radiation," he said. "Furthermore, the patient will feel no pain or discomfort."

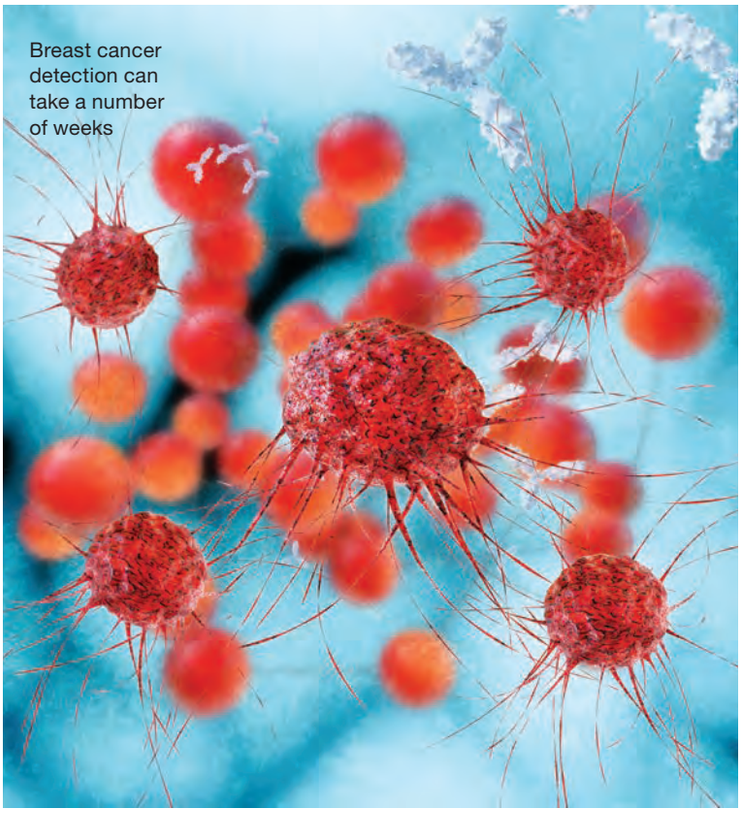
The PAMMOTH (Photoacoustic Ultrasound Mammoscopy for evaluating screening-detected abnormalities in the breast) system operates by sending short pulses of light towards the suspect lesion.

"Light scatters within the breast and is selectively absorbed by blood in the strongly vascularised tumour site," said Manohar. "This absorbed energy is converted into thermal energy and via thermal expansion into a pressure wave."

This pressure wave can be picked up by the ultrasound detectors, he said. "From the detected signals the locations where the initial acoustic pressure was created can be reconstructed, which then gives a 3D map of the presence of tumour vasculature inside the breast."

The system also analyses oxygen levels in the blood around the suspected tumour. Tumours consume oxygen at high rates in order to survive, so lower oxygenation levels around the lesion could indicate that it is malignant.

The system shines multi-wavelength light in the near-infrared range at the tissue. Oxygen coupled to haemoglobin in the blood absorbs light differently at certain wavelengths compared to blood with reduced haemoglobin.



Breast cancer detection can take a number of weeks

ROBOTICS

Up close at Fukushima

Submersible robot explores nuclear plant

Toshiba and the International Research Institute for Nuclear Decommissioning (IRID) have developed a new submersible robot to investigate the Fukushima nuclear plant.

Following the Tsunami-related disaster of 2011, a survey on the primary containment vessel (PCV) of Unit 3 in 2015 found it had flooded with coolant to a depth of 6m. Fuel and debris inside the PCV must be mapped in order to move forward with the plant's clean-up, but the vessel's access point is just 14cm in diameter.

The underwater ROV (remotely operated vehicle) developed by Toshiba and IRID is 13cm in diameter and 30cm long. Once inside Unit 3's PCV, front and rear camera and LED lights will deliver a live video feed to the operators. The radiation-hardened robot will be controlled via a wire, its four rear thrusters and single front thruster guiding it through the coolant.

Toshiba and IRID have already unveiled a scorpion-like robot to investigate the PCV of Unit 2. **AW**

MEDICAL

Devices are a healthy addition to your wrist

Bioassay could be used to monitor blood or sweat

STUART NATHAN REPORTS

A novel approach to lab-on-a-chip diagnostics could lead to health monitoring devices small enough to be worn like a smartwatch, according to researchers at Rutgers University in New Jersey.

The technique, a form of bioassay (which works by attaching traceable substances to molecules known as biomarkers, tell-tale proteins and other molecules that indicate the presence of disease), could be used to continuously monitor blood or sweat.

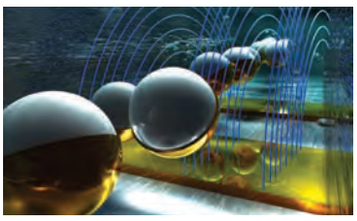
In a paper published in *Lab on a Chip*, the Rutgers team, led by electrical and computer engineer Mehdi Javanmard, described how microparticles, engineered to attach to biomarkers such as prostate-specific antigen (PSA), which often indicates the presence of prostate cancer, can be 'barcoded' so that they can be identified by electronic equipment.

Currently, biomarkers are detected using bulky optical detectors that are too large to be added to wearable or portable devices, Javanmard said.

The technique forms a tuneable micro-capacitor on the surface of a tiny bead of polystyrene. These beads are coated with metal over half of their surfaces with a thin layer of oxide on top; varying the thickness and electrical properties of the oxide layer and the surface area of the bead tunes the capacitance of the bead and allows it to be sorted using electric fields in an electronic device.

Using these beads as part of a bioassay could allow several biomarkers to be detected in a single sample. Also, because detection is fully electronic, the technique allows bioassays to be analysed in a more miniaturised device than previously.

Beads are used as part of the bioassay



DEFENCE

Augmented reality up in the air for trainee pilots

New £2.3m training centre incorporates gaming technologies and advanced military simulators

HELEN KNIGHT REPORTS

The centre simulates various aircraft types

Augmented reality technology will be used to help develop the next generation of military aircraft cockpits, as well as training pilots and engineers, in a multi-million-pound facility built by BAE Systems.

The £2.3m Training and Simulation Integration Facility at Warton, Lancashire, which incorporates gaming technologies and advanced military aircraft simulators, has been developed with Williams Advanced Engineering.

The centre contains simulation capabilities for aircraft types, including BAE Systems' Hawk, Typhoon and future concept aircraft.

Augmented reality and advanced simulation technologies, known as synthetics, can create environments close enough to the real thing as to allow them to be used to offset some of the very high costs of flying aircraft, according to Mark Bowman, director of flight operations at BAE Systems Warton.

The technology will allow the company to place pilots and engineers into environments and scenarios that would be costly to create physically, he said.

"So, for example, if you wanted to conduct a complex mission involving air, land and sea, getting all of those assets into one place at the same time would be very costly and difficult to organise," he said. "But through synthetics you can put the operator into a scenario to maximise their training, without those burdens."

The centre includes a Next-Generation Training Cockpit, designed with Williams Advanced Engineering using F1 technologies. This consists of a twin-seat cockpit simulator, which can be reconfigured to resemble different training and fast-jet cockpits.

An Augmented Reality Environment will be used to create an immersive 3D world for engineers and pilots to improve maintenance and training skills. A Classroom of the Future containing wall-to-wall interactive displays will allow trainees to take a virtual tour of the body of an aircraft using synthetic training aids.

A Networked Synthetic Environment, a suite of connected high-speed desktop aircraft simulators, will allow pilots and engineers to train together.

"The facility is divided into discreet areas that can be adapted for experimentation or training, for example a CAVE-type environment for virtual reality, as well as a number of high-end simulators," said Bowman.

MATERIALS

Polymer is getting as tough as the oyster

Controlling speed of crystallisation is key to new technique

STUART NATHAN REPORTS

Researchers have developed a technique that endows a blend of a polymer with strength and toughness inspired by nacre, a tough-yet-flexible material that lines oyster shells.

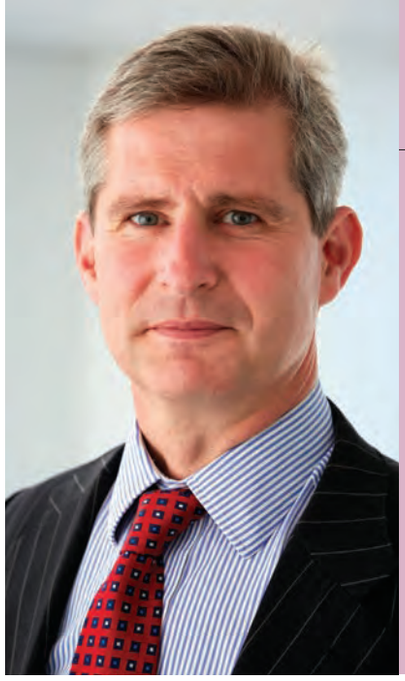
The key to the technique is controlling the speed of crystallisation of a polymer, which is initially well mixed with nanocrystals of different sizes, said Sanat Kumar, a professor of chemical engineering at Columbia University, New York, and director of the research.

Nacre is 95 per cent inorganic aragonite and five per cent chitin, a flexible biopolymer. The aragonite is held together by 10nm-thick layers of crystalline chitin, at scales from micrometre upwards. This structure is the key to the substance's toughness.

"While achieving the spontaneous assembly of nanoparticles into a hierarchy of scales in a polymer host has been a 'holy grail' in nanoscience, until now there has been no established method to achieve this goal," said Dan Zhao, Kumar's PhD student. "We addressed this challenge through the controlled, multiscale assembly of nanoparticles by leveraging the kinetics of polymer crystallisation."

The team mixed nanoparticles of silica with a lamellar shape with polyethylene oxide, a polymer of low intrinsic strength. By varying the degree of sub-cooling it found that it could control how the nanoparticles self-assembled into three different scale regimes: nano-, micro- and macro-metre.

Each nanocrystal was evenly covered with molten polymer before the crystallisation began. The team assembled into sheets of size 10-100nm, and the sheets into aggregates on the 1-10μm scale, during crystallisation.



Brexit coping mechanisms

Engineering companies could cope with Brexit if they knew what changes were on the horizon – but those challenges are still opaque

The recent anniversary of the Referendum gave many people cause to reflect on what they believe Brexit will bring. Famously 'Brexit means Brexit' but seemingly little is settled, and the election has made the outlook even less simple to characterise.

Our future relationship with our nearest neighbours and biggest trading partners is, to say the least, uncertain. For advanced engineering this matters. Our sectors are so thoroughly enmeshed in the European economy and the frameworks in which we operate are so integrated that any change will inevitably lead to dislocation. Businesses can cope with that, provided they know what is going to change and what it is going to change to. At the moment, they don't.

The most worrying uncertainties are around the relationship that the UK will have with the single market after 29 March 2019. This was identified by MTA members as the most important issue or set of issues. It affects the ability of supply chains to function, it affects the ability of UK companies to trade in the EU and it also threatens to upend the regulatory basis on which companies design and market their products. The uncertainty around the status of EU nationals and the abilities of UK citizens to work in the EU is a big issue too.

The MTA regularly meets with ministers and officials working on Brexit to put our members' concerns across but crucially we also regularly meet with our European counterparts to help them understand what is going on on this side of the Channel. We try to put the UK's referendum verdict in its historical context; the overriding importance of the economic rather than political side of the EU to the UK and the strong strain of Euroscepticism that runs through the media. We try to cut through the fog of misinformation and to help European manufacturers understand that industry in UK wants to continue to work with them and maintain the excellent relationships that we have across the continent.

But trying to get across what the British government, or indeed the British people, want can be difficult because there is so little clarity. The government's position crystallised around Theresa May's Lancaster House speech in January but that contained as many questions as answers – what, for example, did "an associate member of the Customs Union in some way" mean? Now that, following the election, the government looks less strong and stable than it did before, the nuances can be hard to read.

We want to enjoy as full access to the single market as possible, to make trade as 'frictionless' and as easy as possible, so that the UK can continue to operate within European supply chains. We also believe that it is essential, in our globalised industry, that we stay within the European Standards architecture – the international recognition of which is so important. We are working with a wide range of companies and other associations to make the standards issues widely understood in government and we were pleased when the White Paper contained explicit recognition of their importance.

Getting clarity on the future is so necessary because businesses need to be able to plan for it. In particular, they need to understand a wide range of factors when arriving at investment decisions. The UK has seen some major votes of confidence in terms of manufacturing investment post-Brexit, with companies such as Airbus, Boeing, Nissan, Toyota and McLaren making long-term strategic investments in the country. The UK has a worldwide reputation for engineering excellence and this has not diminished since the vote last year.

But at least part of the attractiveness is at risk if Brexit is chaotic or leaves the UK isolated. That's why as well as getting the final status right, it is important that there is a transitional period. That will enable businesses to manage the next few years more effectively but will also create a much-needed sense of stability and order. We can't be left with no deal – the world economy is so heavily interdependent that allowing the forest of EU agreements and treaties to which we are party to lapse would paralyse the nation's economic engine.

We see the MTA's role as more important than ever in Europe, we will continue to engage with the UK government and be the unified voice of the UK's manufacturing technologies sector, particularly in relation to standards. We are also committed to our European counterparts and will work closely with the European umbrella associations – of which the MTA is a member – to ensure we move forward together in a positive and constructive way. But one thing it won't be is simple.

James Selka is chief executive of the Manufacturing Technologies Association

Our future trading relationship with Europe is uncertain, to say the least

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Jumping the gender hurdle

Helen Jackson's online piece on how to improve gender diversity sparked a lively debate

While issues such as sexism and salary differentiation remain to be solved, the underlying problem that Jackson mentions is the lack of physics teaching for females.

My recommendation is that we should repeat what was done in the 1950s when many scientists were converted to engineers due to national shortage. Many of the graduates in the sciences could be taught engineering, maths and physics in a one-year course ideally developed by engineers rather than academics.
Jack Broughton

Engineering's labour shortage could be solved in one fell swoop if we can crack the challenge of encouraging equal numbers of men and women into the sector.

Personally I don't believe that it is male sexism that is preventing women from entering the sector because the laws are so strict on this matter and well-run companies won't tolerate discrimination; rather it seems to me that young women interested in STEM subjects lack access to female role models and mentors in engineering.

Our currently woeful female representation is presently compounding the problem of how engineering is perceived by some young women. Change is urgently needed. Indeed it is in everyone's interest that the numbers of new female engineers are significantly boosted.

Bodies such as the EEF and CBI should be driving campaigns to get female engineers into schools to speak to young women. Big engineering corporations who grandstand diversity credentials could be sponsoring women through engineering degrees.
Desmond Gaeney

I've been thinking a lot recently about my own experience as a school student who was sure about a career in engineering. I grew up believing there was no reason I shouldn't and that while there might not be many women in the workplaces I visited I just expected my generation was about to change that. Sixteen years later I cannot ignore the fact that the change I imagined hasn't come.

Recently I've been participating in and organising school STEM events, and sitting on school STEM advice boards as I think it is completely right that young people make decisions and form opinions that influence their career very young. I did before year 9 so I try to offer a broad view of the engineering challenges their generation will tackle and the varied roles they might choose to undertake in that. I also hope having met an engineer who just happens to be female will challenge any unconscious beliefs parents and teachers might have about their students' future options.

For International Women in Engineering day I'll be sharing my STEM session plans on Twitter as I suspect some professionals worry about the prep time and how to create appropriate content. There are many events that require no prep and just a few hours to get great ideas for students.

Doing school STEM events has been a hugely rewarding experience and I believe the best place to champion engineering careers. I am so pleased Helen Jackson has written this piece to bring the action needed to the attention of the engineering community.
Angela Stevenson

This great article was food for thought as my daughters embark on engineering careers – one on the way to becoming a chartered engineer, and one starting an apprenticeship. How to mentor them and help find role models are important issues.
Tim

Inyouropinion

Carrier class?

Weighing up the UK's new aircraft carriers

Why are they not nuclear-powered? The technology is proven and there are those within the Royal Navy that are perplexed by the choice of conventional power and its requirement for a fleet of tankers to follow the ships around the globe to refuel a regular intervals.

Also why were they not fitted with steam catapults for the heavier payload F-35s? If these vessels are to be used to project military power in distant places then surely we need the strongest-possible strike force available.

As with HMS *Hood*, these ships have suffered from defence spending cuts and penny pinching. Let us hope that this particular bird doesn't come home to roost with equally catastrophic results.
Mark Jackson

I am sure that these carriers will act as a deterrent, (especially to third-rate belligerents around the world) but the next proper war will be unlike the last and will probably be fought with high-power computers and computer viruses. Each new generation finds a new route to beat up its opponents when they go to war. Better spend more money on high-power supercomputers and some clever hackers.
Paul Steverson

Hydrogen economy

How far can hydrogen go?

Hydrogen works perfectly well with suitably adapted internal combustion engines and on that basis could save billions of existing engine manufacturing capital assets. The big problem with hydrogen is water-vapour emissions. This could be a big problem, especially in countries with long winters with continuous mean temperatures well below zero, where the steam could quickly form a film of ice on a road surface previously gritted or cleared of snow and ice.
Ed

Heavier and long-distance vehicles, plus propeller aircraft are applications where hydrogen and fuel cells will have decided advantages a long time ahead. If we are serious about getting free from fossil fuels, hydrogen infrastructure must be prioritised. This might not be so costly. As stated in the article, a limited number of strategically placed H_2 refuelling stations are needed. Likewise, a limited number of heavy trucks and long-distance buses are great CO_2 emitters. They could profitably be replaced with hydrogen-driven ones combining public subsidy and private investment.
Jonas Blomberg

Thesecretengineer

Our anonymous blogger searches in vain for some high-quality documentaries

I was recently sat watching a programme about Crossrail on the BBC's second channel. I suspect my initial mistake was that, inspired by memories of the past, I was expecting a high-quality and in-depth documentary. Don't get me wrong, it wasn't very bad, but if you have memories of *Tomorrow's World* then you may have ended up a little disappointed. Two aspects of a sequence about putting in a new over-bridge station

probably sum up the particular issues I have with it.

First, there was the build-up to unloading large sections of the pre-fabricated structure into the car park of an adjacent school. The voice over-dramatically declaiming "…. luckily it's a Sunday and no one is using it…" (or some similar idiocy) saw me turn to Mrs Secret Engineer and say: "There's some poor sod who's spent a lot of time and effort organising things so that would be the case."

I mean, really, are we to believe that such an important aspect was not mapped and planned, that it wasn't seamlessly woven into the intricate scheduling that lies behind Crossrail? Did they turn up on Sunday morning with the lorry and think: "Oh, that's fortunate, just imagine if we'd been here tomorrow?" A minor point perhaps but to be so dismissive of such an important element of our profession is not only a disservice but to actively sell us short in the eyes of the public.

It can only reinforce the seemingly established opinion that some stuff 'just sort of happens'. If you were involved in the planning, negotiations and logistics of that construction, and are reading this – you have my most sincere commiserations.

Second, much was made of the small amount of clearance for craning one of the major assemblies into place. This required more than the usual delicacy as the access was tight and they had to avoid clobberising a tubular steel handrail. Cue breathless narration followed by shots of the piece being hoisted into the air. Add in dramatic music, close in on the edge of a girder being inched perilously close to the hand rail, more excited narration, the music gets more strident… wide shot! Close up! Ever closer! More drama to the music…. until they hacksawed a small section of handrail out so they could get past it. Now, call me old-fashioned but I'd much rather have had a little something about the problems of thermal expansion or the maths behind hoisting such a large and heavy structure.

To return to the start of this, I cannot believe that the public are inherently more idiotic than they were during the 1970s and 1980s. Times when you had *Tomorrow's World*, *The Great Egg Race* and a nascent *Scrapheap Challenge*. Times when you may be lucky enough to catch a *Horizon* special about how a Formula One team (Williams) coped with the rule change that banned sliding skirts or a standalone documentary about the development of the Spitfire as told by an experienced pilot (Raymond Baxter). Times when artificial melodrama wasn't required because the programme makers had the confidence to know that such cheap tricks weren't needed to keep the viewer enthralled by a technically complex story so long as it was told well.

I can only hope that the penny will drop, or fashions will change and we can use the much more sophisticated techniques of today to build on what has gone before rather than detracting from it. The recent 'slow television' programmes, including those showing Mr James May rebuilding various devices, at least give hope.

Join the debate theengineer.co.uk

Looking forward to digitalisation

We need to develop an approach to industrial digitalisation that engages people effectively and ensures the UK benefits from these technologies

In early 2014, the Royal Academy of Engineering hosted a seminal lecture by Henning Kagermann, one of the chief proponents of the German Industrie 4.0 initiative. His presentation set out the now familiar strategy to prepare German industry for a fourth industrial revolution built around cyber-physical systems. It was abundantly clear to those of us who attended that this trend would also be of great significance to the UK and, while it has taken longer than desirable for this to become a UK priority, I am delighted that industrial digitalisation is now the focus of a serious review being led by Juergen Maier, chief executive of Siemens UK.

Last month, the Academy hosted a workshop on behalf of the review team, examining the implications of industrial digitalisation for jobs and skills. Chaired by Phil Smith, chairman of Cisco UK and Ireland, and Graeme Philps, CEO of GAMBICA, who lead the 'skills' and 'jobs' strands of the review respectively, the workshop explored questions such as: what digital skills will be needed in industry to support and exploit digitalisation? How can these skills best be fostered in the current and future workforce? And what is the broader impact of digitalisation likely to be on the creation, displacement and transformation of jobs in the UK? Back in 2014, Prof Kagermann was keen to emphasise that Industrie 4.0 "put human beings at the centre". We will need to do the same if we are to develop an approach to industrial digitalisation that engages people effectively and ensures that the UK is a net beneficiary from these technologies.

Digital technology already permeates and underpins the world around us in a profound way – a trend that is set to accelerate in the years ahead. While digital technology can enable disenfranchised groups to participate in economic activity more effectively, there is understandable concern that the same technology might make it easier for people in other countries, or indeed robots and computers, to displace UK jobs and opportunities.

There is a significant body of data suggesting that in the long term, automation and digitalisation tend to boost employment. One study found that if all industries had the highest observed level of robot intensity, then employment would increase by 7 per cent in the UK. Another concluded that a 10-point increase in the digitisation score would result in a 1.02 per cent drop in unemployment. It has also been argued that industrial digitalisation will shift the focus of manufacturing from mass production and delocalisation to customisation and flexibility of production, with manufacturing increasingly conducted locally.

It is therefore important that the debate over the impact of technologies such as robotics and artificial intelligence (AI) moves beyond predictions of the numbers of jobs that will be lost or created. Instead, it needs to be framed in terms of the changing patterns and content of jobs, the skills sets that will be required and the policies that will bolster UK productivity and competitiveness as digital technologies become more pervasive. The fact that UK industry didn't embrace the so-called third industrial revolution (driven by automation) as fulsomely as some of its international counterparts may create a strategic advantage, potentially allowing us to be more agile in seizing the opportunities for new products, services and business models enabled by digitalisation.

Digital technology already permeates and underpins the world around us

For that to happen, the UK must substantially improve its performance in digital skills. Just 17 per cent of employers responding to a recent survey conducted by BDO and the Institution of Mechanical Engineers said that they have the right staff and skills to incorporate Industry 4.0 into their businesses. As well as ensuring that digital skills become embedded in our education system, we need to put in place much better systems to support lifelong learning. We also need more effective guidance, and stronger links to industry, for those involved in education and training provision so that providers understand the skills and knowledge that are going to be of value to learners, both today and into the future. The task of raising skill and knowledge levels to support our adaptation to digitalisation must be taken up right across industry – from the factory floor to the boardroom, and in companies large and small – as well as across academia and government.

The engineering community must also ensure that its structures and activities adequately reflect the collision of the physical and digital worlds. We need to be a central part of the response to industrial digitalisation, whether informing public policy or supporting the delivery of future-proof training and approaches to professional registration. Our expertise will be crucial for building secure cyber-physical systems and we will need to work with the public and policymakers to build trust and confidence in them, while systems engineering approaches will be vital for building resilience in an ever more interconnected world.

The Academy looks forward to working with colleagues across the engineering profession, industry and government to make sure that Juergen Maier's review has the long-term impact required to secure our future competitiveness.

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

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Out of the box

Additive manufacturing is being freed from its confines through integration with robotics. Is this the future for the sector?

Stuart Nathan reports

Additive manufacturing is no longer a novelty. Over the past decade the technique of building components and even some finished products by layering materials on top of each other has been increasingly accepted. The sector is still developing, however, and new developments come along frequently.

While additive has many advantages, such as its ability to build complex geometries, it is still a limited technique in several ways. A striking example is that it is an 'in the box' process: components are built inside dedicated machines that are sealed away from the outside environment.

However, a trend is developing that frees additive manufacturing from its confines by integrating it with robotics. Could this be the future for the sector?

Robotic additive manufacturing has existed for some time, according to Phil Reeves, vice-president for strategic consulting at additive specialist Stratasys.

"It's not recent in a research domain," he said, "but it hasn't really found its way into a commercial domain until the past couple of years."

Two factors are driving this development: a need to build larger components than are possible with conventional enclosed additive devices, and a desire to integrate additive manufacturing with other conventional automated production systems, such as machining.

"Robots have been part of integrated production for many years, whereas, if you think about 3D printers — especially open architecture, by which I mean devices you can plug into a SCADA system on a production line — they are still in their infancy," Reeves said. "There's also the fact that additive manufacturing often requires some post-processing, whether that is some machining to pick up physical data points, post-process inspection, surface finishing, sanding or painting. And in fact all these processes are done by robots in industry. So integrating your additive machines with a robot means you can develop a whole production architecture around robotics."

Currently, most robotic 3D printing is carried out by mounting a deposition effector on either a robot arm or a co-ordinate system; that is, a printing head sliding along a beam that itself slides along rails on a gantry. This type of technology originated in the welding sector, Reeves said.

"If you go back 20 years or so, there were research projects involving placing arc-welding heads onto robots and using that as a way of depositing material. Now that has been taken many stages further, for example at Cranfield University, where they have been developing a system they call WAAM — Wire and Arc Additive Manufacturing — which is capable of very sophisticated processes. So metals were in fact established first, but we are starting to see different polymer heads being integrated into this kind of system, using predominantly extrusion techniques but also some technologies with photocurable resins."

An example of this, Reeves said, is an Israeli system called MASSIVIT, which is equipped with two robot arms and extrudes a gel with a toothpaste-like consistency that is cured by UV light; it is capable of building items up to 1.8 x 1.5 x 1.2m in size.

Stratasys itself last year produced a robot composite demonstrator machine with an FDM (fused deposition modelling) head on a robot arm. FDM is Stratsys's trademark technique, building items from extruded thermoplastic filament.

Of course, as with many engineering techniques there are trade-offs. What robotic additive manufacturing gains in its ability to produce large objects and integrate with other processes, it loses in precision.

East London-based Al Build illustrates neatly the point about the value of control. Using fairly simple hardware – polymer-filament extrusion heads on standard six-axis polar robot arms from manufacturer Kuka – the company focuses on the built environment, using AI software to plan the movements of the arms and ensure accuracy and structural integrity. Al Build produces items measuring up to 3.2 x 2.4 x 2.8m in multiple materials, which are used at trade fairs, in art galleries and at universities; the striking 5 x 5 x 4.5m pavilion structure on our front cover was made in 48 parts from 160kg of biodegradable filament.

"Robots are not the most accurate things in the world," Reeves said. "You have to spend a lot of money on a very large-capacity robot to get any sort of accuracy out of it. So what we're seeing being built in this space at the moment is a lot of lower-accuracy components, often the sort of thing that might have been built by fibre-glass lay-up before.

"MASSIVIT, for example, is focusing on the advertising and entertainment industry, so its customers are producing things like components for theme-park rides and point-of-sale and retail display. We might expect that to go into components of large-scale transport systems: things like the outer bodies of trains and trams, or even furniture; items where you are less reliant on accuracy but you require scale at an affordable price. There are some large-bed closed-architecture 3D systems but they tend to be expensive, so items produced on them are also expensive."

The welding sector is still very active in robotic additive manufacturing. The Welding Institute (TWI), the Cambridge-based organisation that pioneered metal additive techniques, developed a series of systems that used robotics to control deposition heads, and used them to build highly accurate aerospace components.

Carl Hauser, a TWI consultant in additive manufacturing based in Leeds, explained that he uses laser metal deposition (LDM) – where a laser creates a 'melt pool' on a metal substrate into which powdered metal is fed (this developed from laser cladding processes) – to produce casings for aircraft engines and gas turbines. "This is large-scale stuff that would be too big for a powder-bed system but is very well suited for this type of open architecture," he said. "We build thin-walled structures, from 800µm to 2mm thick, and from 300mm up to 1.5m in diameter. Conventionally, these would be built by forming thin-sheet materials and welding them together, but the additive technique gives significant time compression and gets past another problem: you get a lot of distortion when you weld thin-sheet materials, so these components often need a lot of machining to tidy them up afterwards. The casings we produce by LDM are net shape and within tolerance; we tend to use gantry systems to move the print head, which stretches the definition of robot for some people but has greater accuracy than robot arms."

01 Siemens is incorporating additive into spider robots

Although the TWI techniques' origins are in welding, they have developed to the point where they are a category in themselves. "But there are still fundamentals from welding that are useful, which are related to material properties," said Hauser. "You're creating a melt pool and using a metal consumable."

Other techniques from welding are also useful, such as using an inert gas to shield the working zone. "That's fine for alloys like Inconel," said Hauser, "but for more reactive metals like aluminium or titanium we need to put the whole piece in an enclosure so we can control the atmosphere around the molten metal. We generally use a flexible plastic bag arrangement rather than a box."

Hauser added a note of caution. "These robotic techniques have to be taken on a case-by-case basis, and there are notable limitations. With a powder-bed technique, you can print overhanging features because you print support structures at the same time as your component and the powder bed itself supports the part. Anything that you make using robotic additive has to be free-standing and self-supporting; although you can print overhangs to an

Spider bots collaborate for additive

A potential vision of the future could be taking shape at Siemens Robotics Labs at Princeton in New Jersey, where a team of engineers is developing autonomous robots equipped with vision, processing and additive manufacturing systems, designed to co-operate on additive manufacturing tasks. In the form of robotic spiders, the systems are aimed at applications such as collaborative manufacture of automotive bodies, ship hulls or aircraft fuselages, explained project leader Livio Dalloro, head of Siemens Product Design, Modelling and Simulation Research Group. Like several concepts in mobile additive manufacture, the Spider bots grew out of a concept to build bases for exploration on the Moon and other planets. Still in development phase, the Siemens Spiders currently print in a mixture of cornstarch and sugars, but plastics and even concrete are possible for future generations. The aim of the project was to develop manufacturing machines that could autonomously evaluate a task, divide it between themselves and collaborate to complete it. For example, when an individual robot reaches the end of its battery charge, it transmits its position to a fully charged unit that can take over while it recharges.

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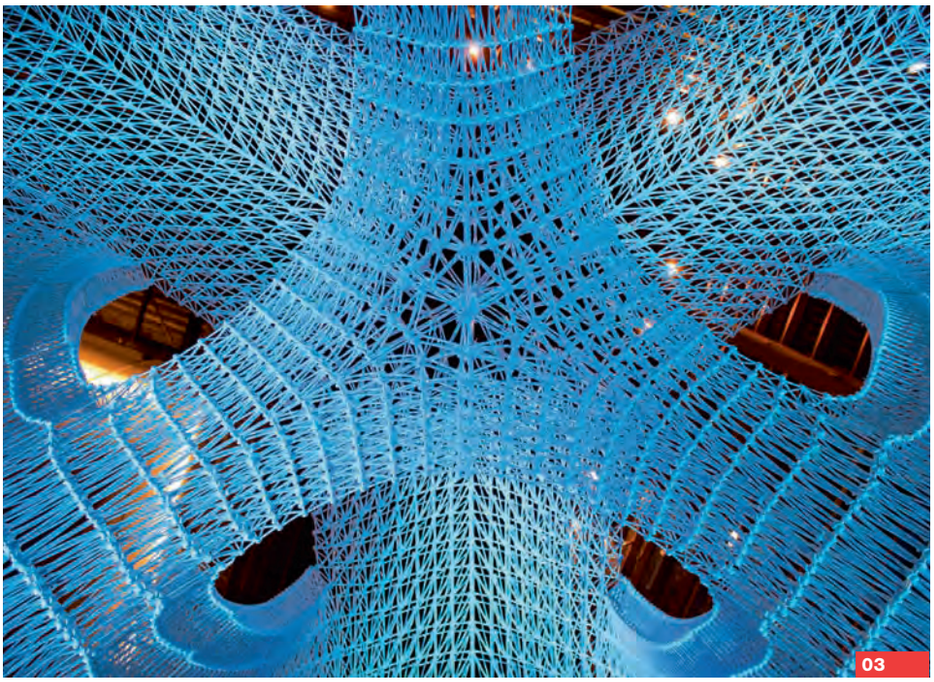

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02 AI Build's robots can make large structures with precise geometry

03 Detail of a large pavilion structure made by AI Build

extent by reorienting and manoeuvring the substrate, which is another advantage of being in the open and not 'in the box'. It may be possible to actually form support structures in this way, although we haven't done that yet because we haven't found an application where it is needed. But future developments will see us going in two directions in terms of what you print: finding out how big you can go and also how complex you can go."

Reeves' predictions are more ambitious. "We will definitely see machines and hybrids increasingly integrated into production lines, which in a way is an extension of something we already see. It's not a big step from machines that deposit adhesives onto a surface to machines that deposit more structural materials," he said. "We've seen lots of proposed configurations, through to putting 3D printers onto drones, and schematics of things like surface crawlers that do repair. So if you take a large ship or vessel that requires repair or cladding, you have a robot equipped with optics that detects if something has a crack in it or is worn down, deposits material, potentially polishes it, rescans it and so on. I'm sure at some point we will see this on more intelligent robots with AI built into them." (See box on p23.)

What Reeves describes is essentially remanufacture: removing worn or out-of-tolerance material from a component and rebuilding it by depositing fresh material. This already seems well suited to robotic additive processes, particularly as they need to be combined with conventional subtractive techniques. Remanufacture is a focus of TWI's work with LDM — repairing mould tool surfaces and high-value aerospace and defence components — and is being investigated by Rolls-Royce for repairing worn jet engine turbine blades. It is also the stock-in-trade of Hybrid Manufacturing Technologies, whose chief executive, Jason Jones, is identified by Reeves as a pioneer in integrating additive techniques with robotics.

"The background of why we do this is twofold," Jones told *The Engineer*. "One is that conventional additive manufacturing doesn't deliver the surface finish and accuracy we were accustomed to with more conventional CNC machining, so part of the motivation was to be able to build a part and finish it in situ in a single set-up.

"The second motivation was to combine several types of additive technique in the same space. We took part in a four-year project funded by the Technology Strategy Board — now Innovate UK — and eight or nine companies including Renishaw, Delcam and TWI. We were able to demonstrate a fully automated remanufacturing solution that involved taking an old component, measuring it, removing material that was worn out, using additive techniques for metal deposition and then switching over to machining, all using a machine-tool platform. We chose a standard tool-holder to be the interface by which you pick up and move the item around the various operations. As far as I'm aware, that was the first attempt to modularise additive and integrate it with other platforms using an open architecture."

> "Integrating your additive machines with a robot means you can develop a whole production architecture around robotics"
>
> Phil Reeves, Stratasys

According to Jones, robotic techniques are particularly suited to additive processes that use harder and more rigid materials. He conceded that open-architecture systems have limitations, "but we're very comfortable out of the box".

Despite the promise of combining robotics with additive manufacturing, there is general agreement that it will not displace conventional 'in the box' additive manufacturing but replace it as a tool for particular applications.

"If you're using FDM-type heads it will probably work, but if you're using powder it probably won't," said Richard Hague, director of the EPSRC Centre for Additive Manufacturing at the University of Nottingham. "Of course, you can use systems where you blow powder into a laser beam, but you don't get the resolution and you also get better geometrical freedom from powder-bed and layer-by-layer systems. Hybridisation of systems will increasingly happen but there will be no perfect solution; it will depend on the application."

For example, Hague said, a robotic system may be suited to making large aerospace parts but, "if you're making thousands of hearing aids using a powder-bed additive process, why would you want to go to this type of system? If you're making knee joints where you want complex surfaces and complex geometry, it would be really hard to get out of the powder bed."

Reeves conceded that additive manufacturing had been the subject of inflated expectations, and still suffered from this. In the early days of the technique, companies such as Airbus talked about one day being able to print a whole wing, he recalled.

"The scale of that isn't a problem if you look at the type of gantry system the aerospace sector uses now. But the multimaterial aspect is; wings use composites on the outside and structural materials like aluminium and titanium on the inside. Are you really going to be able to print both? It might have been better if people had been realistic back then and said: 'We're aiming to make a 4m-long wing spar from titanium using a robot and a wire fed into an electric arc.' That's not very sexy, but it actually is the state of the art."

Chain gang

New database technology could be a game changer for many industries. Andrew Wade reports

So, what exactly is blockchain? It's a distributed database technology that records and timestamps transactions in blocks, creating a chain that acts as a ledger. The ledger is decentralised across multiple computers, making it virtually impossible to retroactively alter, and thereby inherently secure.

Readers will be familiar with bitcoin, the digital currency that introduced the world to blockchain. Bitcoin transactions do not require a trusted third-party, theoretically making them more efficient, as well as secure. However, it is not just financial transactions where trust and security are desirable, and a new wave of innovation based on blockchain technology is seeking to disrupt a whole range of industries. But is there substance beyond the hype?

"Blockchain is on the steep upward path to the peak of inflated expectation, which means it's going to be on its way down pretty soon," explained Accenture's Craig Gottlieb at PTC's Liveworx conference in Boston. "But that's not to say that there aren't practical, pragmatic applications for the technology."

Gottlieb is a principal director in Accenture's Aerospace and Defence Practice. These are sectors with a high degree of complexity, involving intricate supply chains, multiple stakeholders, and generally a strong requirement for security. The multitude of moving parts can engender a lack of transparency and efficiency.

"Where blockchain comes into play – and why it's cool – is that it starts to solve some of these problems," said Gottlieb.

A traditional, centralised ledger is owned by a single entity, with changes generally not shared. In contrast, blockchain distributes ledgers across multiple decentralised nodes, with stakeholders coming together to form consensus on transactions. As the entries are immutable, there is a permanent audit trail that can be reviewed in case of disputes.

The bitcoin blockchain allows parties to transact anonymously. Actors are not known to each other, but can interact securely due to the nature of the system. This has led to bitcoin and other digital currencies being adopted for nefarious purposes, such as buying illicit drugs on the dark web and paying ransom to hackers in the wake of cyber attacks.

But just as cybercrime hasn't thwarted internet adoption, these practices aren't preventing blockchain being adopted for legitimate ends. Companies are exploring private blockchains, where parties known to each other participate inside closed systems. Although some don't consider these systems to be genuine blockchains – rather distributed ledger technology (DLT) – most agree they have potential. In fact, DLT has advantages over 'pure' public blockchains such as bitcoin.

Public blockchains need large amounts of computing power, and in some cases a lot of time, to generate new blocks. Bitcoin transactions can take up to an hour, something the community is trying to solve, but that is causing tension between stakeholders and impacting the coin's price. Solutions are being tabled to speed up transaction consensus, but no agreement has been reached yet.

Private blockchains and DLT are not faced with these systemic scaling issues. Agreement on transaction consensus doesn't require the same cryptographic rigour, so can occur quicker and without the overheads of computing resources.

01 Aerospace production has a high degree of complexity

02 Bitcoin introduced the world to blockchain

03 Ciaran Murray, founder of Verbatm

"DLT requires industry consortia to come together"

Ciaran Murray

"There are faster mathematical means to achieve that consensus," said Gottlieb. "From a business standpoint, where speed matters, that format makes a lot more sense."

One area suited to DLT is configuration management, particularly on complex systems such as aircraft. According to Gottlieb, maintaining visibility over every part of an aircraft during its lifetime is a challenging task.

"Maintenance, repair and overhaul organisations obviously update the configuration of an engine during an overhaul," he said. "If they don't have visibility to the current configuration of what needs to be done, they can't schedule their capacity effectively."

On top of this, the business models of OEMs such as General Electric rely on the accuracy of the data they use.

"They sell service plans," Gottlieb continued. "And these are optimised around when overhauls happen, what spare parts they can sell etc. Their ability to optimise the profitability of those, and the availability of the aircraft, is rooted in knowing what's on the engine at any given point in time."

While Gottlieb believes blockchain can help address these issues, others are more sceptical. Purely digital transactions can be governed exclusively by economic incentives and cryptography, but transactions that incorporate action in the real world still require an element of trust.

"Immutable digital records of ownership are incompatible with an analogue world where misunderstandings and errors are commonplace and the state is the arbitrator in case of dispute," said Ciaran Murray, founder of consultancy Verbatm. "When you're dealing with supply chains, you're dealing with physical objects in the real world, off the blockchain. There's no way the blockchain can maintain jurisdiction over them, as the nation state rules supreme in the physical world."

Although blockchain cannot have physical jurisdiction over things such as configuration management, it can act as a strong incentive to act in good faith. If one party claimed to have replaced an engine part, but a quick reference of serial numbers on the blockchain revealed otherwise, that party would be liable. In the world of aerospace, consequences could be severe.

As far as public blockchains go, there are questions as to the breadth of their utility. Murray believes their use will be limited to digital currencies, decentralised over-the-counter exchanges, and perhaps prediction markets. We've already seen the technology challenge established views on decentralisation and its possible benefits. DLT may not have as profound an impact, but could potentially operate across any industry. In highly regulated fields, Murray believes DLT will hold greater sway, as it is compatible with existing legal and arbitration systems.

"DLT, as opposed to anarchic public blockchains, may have utility in increasing transparency and constraining corruption while possibly decreasing friction in certain areas, but it requires industry consortia to come together," he said. "The barrier is organisational, not technological. However, the result might not necessarily be good for the consumer, with a potential opportunity for cartels to form."

The burgeoning IoT industry is another where expectations of blockchain's impact are high. With billions of connected devices due to come online in the coming years, blockchain could play a key role in device identity.

"If you want to have a good IoT, you need to have a good identity of things," said Gottlieb. "You need to know that the device that's sending you information is a device you can trust."

But Murray, again, urges caution. Having seen blockchain evolve since its early years, he is pragmatic about its limits, and warns against the current hype surrounding the technology. "There's no doubt decentralised identity is more secure and an insecure IoT is quite a scary proposition, but a ledger that maintains an indelible record of identities is an even scarier one. In any event, the ability to repudiate digitally signed statements is a well-established legal doctrine in most nation states, so the idea is currently legally unworkable."

Relatively speaking, blockchain is an incredibly young technology, the long-term impact of which is hard to predict. True believers claim it will transform society, while others are suggesting that the emperor may be underdressed. Part of the fascination over the coming years will be seeing who is right.

Making a power of difference

U-Battery's general manager explains the thinking behind the latest generation of small modular reactors. Stuart Nathan reports

Small modular reactors (SMRs) are a key part of the UK's nuclear future. The previous chancellor of the exchequer, George Osborne, said so repeatedly, committing funding to their development, and his successor, Philip Hammond, has reaffirmed the commitment.

A competition is currently running — somewhat behind schedule — to pick a design to receive more funding and be taken forward to a first-of-a-kind demonstrator and future plants, to serve both the UK and, it is hoped, a large export market.

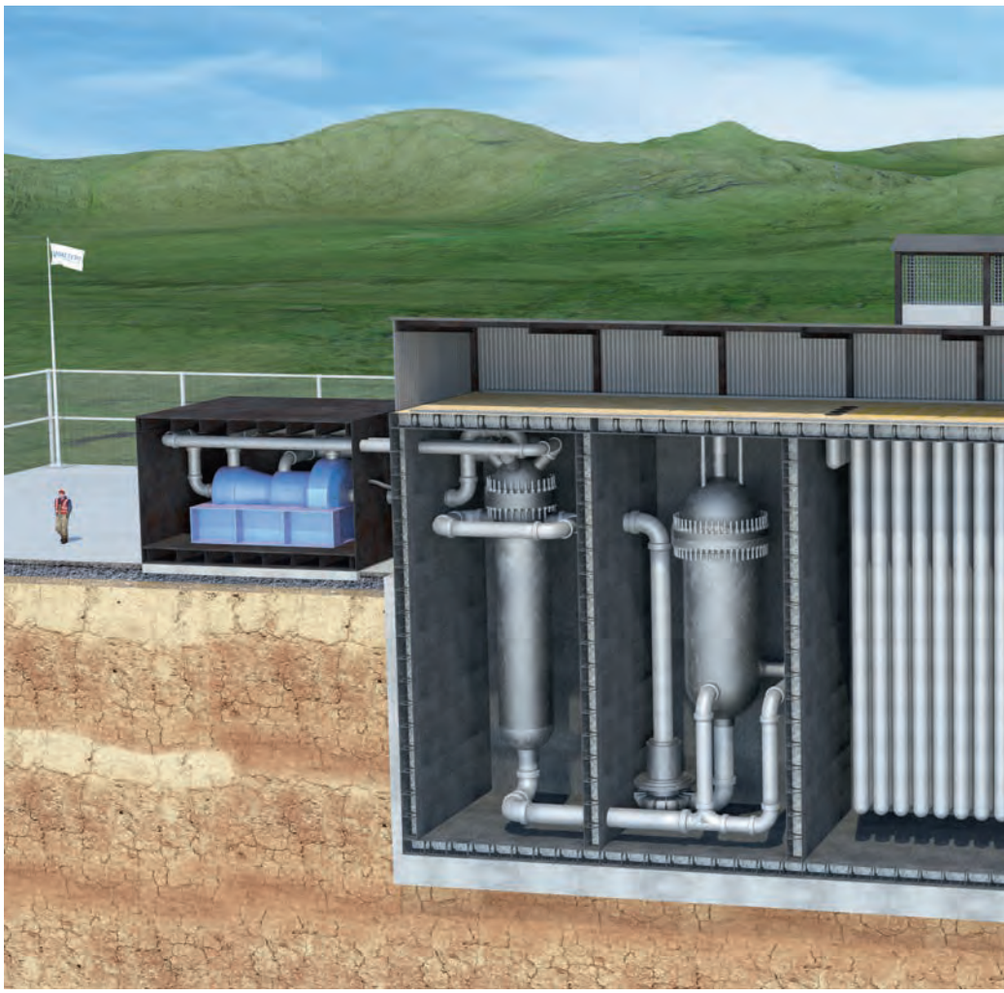
SMRs contradict the previous thinking behind nuclear reactors, which can be crudely summarised as 'bigger is better'. This economy-of-scale thinking has been proved numerous times in many sectors – basically, it does not cost twice as much to build a plant with twice the capacity — but in nuclear it doesn't seem to have worked. As time has gone on, nuclear reactors and their associated hardware have become increasingly complex, with more and more safety systems being added, with the result that they are so complex to build that even the most prosperous countries are strained to finance them.

The thinking behind SMRs is that another mechanism for reducing costs, mass production in factories – which has been proved across several sectors — will unlock savings. Break down a plant into modular systems that can be made in a central factory, construct and test those systems in these controllable surroundings, then assemble them on site, and the whole thing will be cheaper. Moreover, smaller plants can serve individual communities in countries that do not have the large, complex power grids of Europe and the US, or are remote from them.

Most of the SMR designs competing in the UK and, indeed, being developed elsewhere are scaled-down versions of the pressurised water reactor (PWR) technology that has dominated the mainstream nuclear market for decades. An exception is U-Battery, a design promoted by a company formed by a consortium of nuclear and other engineering firms, including Amec, Cammell Laird, Laing O'Rourke and Nuclear AMRC. U-Battery general manager Steve Threlfall recently met *The Engineer* to discuss progress on the design and explain how it was suited to a different range of applications from those of other reactors.

In some ways, the U-Battery system harks back to an earlier generation of reactors. Rather than being cooled by water, it is a high-temperature gas-cooled reactor (HTGR).

"We use Triso fuel," Threlfall said. These are spherical pellets with fissile uranium, in an oxide form, at their core, surrounded by layers of carbon and silicon-based ceramic.



"We're trying to address this different market where nuclear hasn't been before"

"There are two things you can do with that. You can put it into tennis-ball sized spheres in something called a pebble-bed reactor, which was developed in South Africa; or you can do what we do, which is to use a prismatic block design."

In this, he explained, Triso particles are embedded into pellets called compacts, 39mm x 26mm, which can be assembled into something like conventional nuclear fuel rods. These then go into the core, which is assembled from an array of 24 hexagonal graphite blocks 80cm high — the prismatic blocks of the name. These are pierced with holes that run axially up and down the reactor. Some of these holes contain fuel, some control rods, and others allow the coolant gas — helium — to circulate. Rather than boil water

to create steam, the hot helium goes into a heat exchanger, warming a secondary coolant that expands, driving it around its circuit.

"It's nitrogen in the secondary circuit, and that blows a standard turbine around," Threlfall said. "We use nitrogen because it's as close to air as you can get, which means we can use a standard off-the-shelf turbine. It helps keep the economics in good shape.

"There are very few actual nuclear components; it's just those graphite blocks, the fuel itself, the pressure vessel and the heat exchanger. Everything else is standard equipment like you'd find in any conventional gas-fired power station. We keep it really simple."

An advantage of this type of reactor is that all the fission breakdown products are kept inside the Triso particle, which, unlike the fuel in an SMR, cannot melt if coolant in lost.

"If you take out the control rods and let the helium escape, the temperature will go up from the operating temperature, 700°C, to about 1,100°C — and the fuel is proven safe up to 1,600°C. The graphite expands, the neutrons escape and it shuts itself down," Threlfall said. "Prof Tim Abram of Manchester University, who designed this type of reactor, has sat on a Triso reactor in China with the safety systems turned off with no ill effects."

Triso, though not currently in use with commercial reactors, has a long history. "Triso fuel has been under test in the US for 13 years, and before that it was used in the UK at the Dragon reactor; it's Technology Readiness Level 9," Threlfall said. "It's performed way better than anything we'd need."

Triso is not currently used because it is best suited to co-generation of heat and power, rather than the pure power generation for which SMRs are optimised, which has been the dominant paradigm for using nuclear. Now that the use of fossil fuels for heating is receiving more scrutiny, U-Battery believes that Triso, which can provide both heat and power with no carbon emissions, is a technology whose time has come.

"It hasn't been done before because we're trying to address this different market where nuclear hasn't been before," Threlfall said.

Although U-Battery is trying to get the reactor into the UK's SMR competition, it has an eye on other markets: two in particular. "There's interest in the UK, Canada and Poland. Ideally we'd like to do all three simultaneously but things work at different speeds."

In Canada, Threlfall explained, U-Battery units could serve the many small mining communities based around the Hudson Bay and Arctic Circle. "Today they run diesel generators; they're dirty, not so reliable and incredibly expensive to run because of the cost of getting diesel to these places on ice roads or by air." A single-reactor U-Battery plant, providing 10MW of heat and up to 4MW of electricity, would be ideal for communities of between 200 and 12,000 people, Threlfall said.

The situation in Poland is slightly different. "There is a great interest in Poland to replace boilers on existing industrial sites with a nuclear heat source; to replace coal or gas from Russia and improve their energy independence."

The design for U-Battery has yet to reach a working prototype, Threlfall admits. "Over the past 12 months we've gone back to the universities that originally designed the system, and broken it down into individual components and got a costing for each of them, particularly the large nuclear components," he said. This yielded some pleasant surprises.

"We went initially to Sheffield Forgemasters for the pressure vessel and they said: 'Actually, it's so thin and small that you wouldn't really want to forge it; you're much better off fabricating it.' So we went to Outokumpu in Sheffield and they did some costings for a welded pressure vessel in a nuclear-grade steel – so much cheaper than forging."

The company now needs to expand its design team for front-end design and intends to go straight to building a first-in-class plant rather than prototyping.

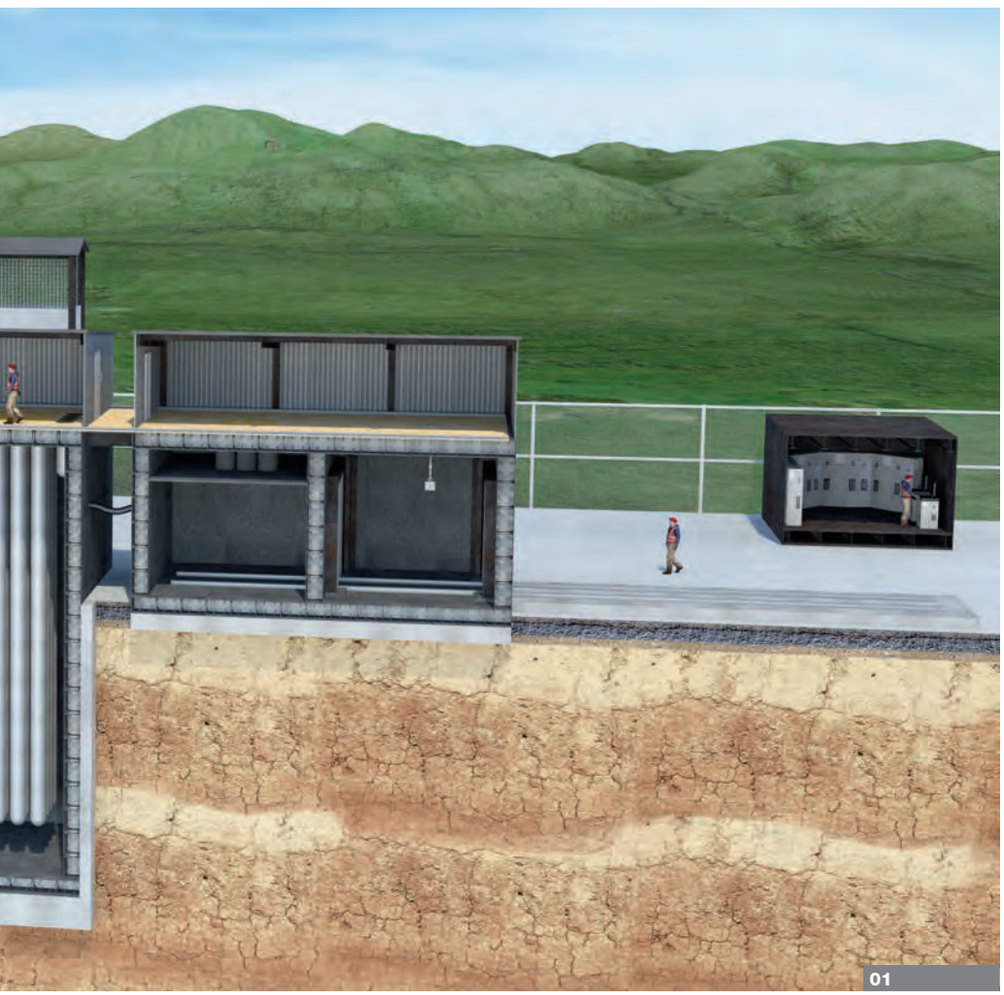
"Canadian Nuclear Laboratories has offered us a site, Chalk River, just north of Ottawa, and we are in discussion with the Canadian utilities. Chalk River has an operating reactor that produces a lot of medical radioactive isotopes but it's going to close next year." The company is also eyeing a Polish site, Swierk-Otwock, north of Warsaw, which houses the Maria research reactor.

In the UK, U-Battery needs to ask BEIS for permission to go to the Office of Nuclear Regulation to have its design assessed for approval — a political step that is not required in Canada, for example, where regulators are already assessing the design. UK site selection would follow from the regulation.

"We'd want to go for a site with an existing nuclear licence, and there are plenty of those," Threlfall said. "But ideally we'd want a site suited to co-generation, with industries that could use our heat. Glass, ceramics or chemical processing would all be ideal."

Because of the simplicity of the U-Battery reactor, Threlfall believes it could be in operation before any SMR-based designs, even in the UK, where other partners in the company are bringing their expertise to the task.

"We're aiming for a mid-2020s start-up for our first-of-a-kind plant," he said. "And we've also had interest from India and Malaysia."



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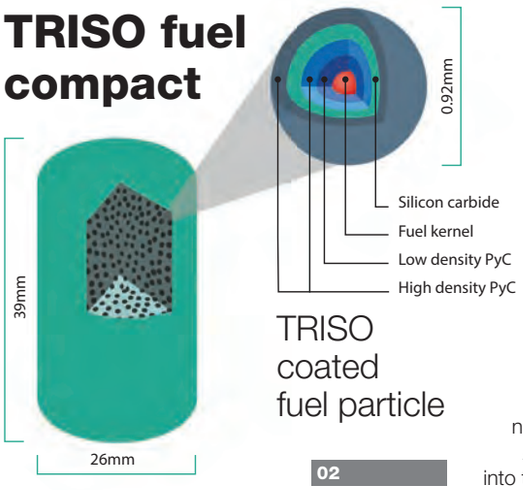

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01 The U-Battery plant occupies about the same area as the penalty area on a football pitch

02 Triso fuel is proven safe up to 1,600˚C, well above its operating temperature

Degrees of freedom

Can degree apprenticeships achieve a meaningful increase in engineers? Will Stirling reports

Applications for UK engineering degrees and apprenticeships are increasing, but nowhere near as quickly as they need to in order to fulfil the demand from industry. In addition, the profession needs to attract more women and older workers.

Alternative routes to training have emerged and, for a capable candidate with the right aptitude, employer and budget, there are several means of gaining engineering qualifications. Increasingly, age is less of a barrier to entry.

One route is the degree apprenticeship, which combines aspects of higher and vocational education and is designed to test both academic learning and occupational competence. This can take students to Level 7 learning, equivalent to a masters degree. The obvious attraction is of obtaining a university degree not only without having to pay tuition fees but also while earning a salary as an employee. Although these qualifications can be seen as disruptive to traditional university degrees, they offer great promise, especially to older students and those with jobs in industry, as an alternative to traditional campus-based higher education.

The introduction of the Apprenticeship Levy in April 2017 may well catalyse their development. A spokesperson for HEFCE, the Higher Education Funding

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Council for England, said: "The impact of the introduction of the Apprenticeship Levy is likely to lead to an increase in demand from employers for degree apprenticeships for many subjects, and, as awareness of degree apprenticeships increases more generally, more and more individuals seeking higher education opportunities and increased employability will pursue these options."

A growing number of universities are offering degree apprenticeships in engineering and manufacturing, including Cranfield, Lincoln (food manufacturing), Middlesex, Sheffield and Sheffield Hallam. Sustaining these courses can depend on buy-in from employers, which ultimately fund the places. Loughborough university tried to launch a Digital and Technology Solutions degree apprenticeship in 2015, but it was discontinued.

Cranfield University has run its Level 7 apprenticeship since 2005. "The SEMAP, or Systems Engineering Masters Apprenticeship, was the very first Level 7 to be created; we are now on the third cohort for this offering," said Dr Emma Sparks, head of centre for systems engineering at Cranfield Defence and Security. The all post-graduate university later coined the term 'mastership' to help candidates determine the route to a masters degree. The course has two intakes a year, with over 30 students in each intake, and has always been well subscribed.

Can anyone apply for a Level 7 apprenticeship? "Entry criteria are typically a combination of experience and qualifications," says Dr Sparks. "[For a candidate] with no qualifications, we would look for a minimum of 10 years' experience to enable them to start the academic component of the apprenticeship. If they had done a Level 4 or 5 apprenticeship, this would count with a smaller period of experience."

Both military and mature students in industry in particular tend to be short on academic qualifications but long on experience. Older students nowadays have more routes to manufacturing training. Legally, universities cannot discriminate by age, but often the cost of study and entry requirements limit the applicants.

Cranfield also runs an Operations Excellence course where the average student age is 33. "The Operations Excellence MSc is an appropriate course for applicants who are older and may not have a first degree. It is part-time for people who remain in work," said course director Dr Patrick McLaughlin. "The course is about developing people who can design and lead change to deliver operational excellence – very appropriate considering the poor productivity record in the UK," he added. "As such, it focuses more on 'how' and 'why' rather than 'what'." Candidates from non-technical backgrounds such as marketing and business studies have done well on the course, and 190 people in total have graduated since 2003.

When Local Enterprise Partnerships (LEPs) took over from the abolished Regional Development Agencies in 2012, it was a sign of small government giving the private sector more responsibility – but less cash – to develop skills locally. A training programme spawned by LEPs is the Trailblazer framework, designed for groups of employers that work together to design new apprenticeship standards for occupations within their sector. The idea is to match the training specifically to a company's or sector's needs.

A good example of this model is the new Marches Centre of Manufacturing & Technology in Bridgnorth, due to open in September. Engineering employers in Shropshire had recognised a problem in common: many of their employees approaching retirement were unlikely to be replaced by skilled younger recruits. So they built their own training school. Four employers – Classic Motor Cars, Grainger & Worrall, In-Comm Training and Salop Design & Engineering – formed a Community Interest Company to operate the centre, with over £2m of funding from the LEP. Sixty-eight apprenticeship places are available in the first year and the centre is four times oversubscribed.

"Training older people for new careers in engineering is a key target for us, the MCMT and InComm," said Chris Greenough, commercial director at Salop Engineering. "With the new changes in apprenticeships, there is no maximum age limit – something that has not really been advertised."

More Trailblazer framework centres are springing up, and apprentices can also study to Level 7 at the Advanced Manufacturing Training Centre at the MTC near Coventry and the AMRC Training Centre in Rotherham.

Another growth area for recruitment to manufacturing is former armed forces personnel. The Career Transition Partnership, operated by the Ministry of Defence, is devoted to resettling ex-military personnel in new careers, and manufacturing is the most popular sector. Companies including 3 Sun, Adnams, igus UK and Morgan Marine & Envico Engineering have successfully employed ex-forces personnel.

Such schemes are gradually widening access to engineering in the UK, but a lot more needs to be done.

01 Students on Cranfield's mastership programme

02 Apprenticeships are valuable for improving experience

"Entry criteria are typically a combination of experience and qualifications"

Dr Emma Sparks, Cranfield Defence and Security

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Face up to the future

Novelist Jon Wallace considers the science fiction implications of engineering stories that have caught his eye. This month, the threat of facial recognition technology

To most, engineering still evokes the best parts of humanity: curiosity; adaptability; doggedness. It's that which allows us to apply our restless spirit to noble pursuits: shaping the landscape, augmenting our impressive natural senses, and consolidating our dominion of the Earth. For many, engineering advances are the measure by which we mark our species' progress.

Still, every now and then, a story crops up in *The Engineer*'s news feed that might seem contrary to this spirit of enlightened advance. The effort to perfect facial recognition technology by Bristol Robotics Laboratory's Centre for Machine Vision is one such. "Our 3D solution provides pinpoint accuracy," boasts a spokesperson. "For national or high security… our solution provides an extra layer of confidence."

Indeed, what utility has the technology for augmenting the already considerable arsenals of state surveillance and marketeers? There is something seedy about it. At least the fingerprint has the benefit of imminence – when the border guard at JFK tells you to present your thumbprint you are, like it or not, wilfully participating. The facial recognition scan, on the other hand, is designed to occur without consent: where CCTV can be said to monitor a particular area, facial recognition monitors us. A fingerprint is the smudge we leave on the world, whereas the scan smears us all.

Perhaps we should get used to it. In the Facebook age we've all mortgaged our features to some extent. But to the scifi author, facial recognition throws up some troubling questions. After all, our face is our flag, our uniqueness in the crowd. Altering it has the potential to make other people of us; and there comes the opportunity for story.

Faces have a crucial role establishing the world of scifi stories: the smallest prosthetic bumps and ridges suffice to suspend our disbelief in a *Star Trek* universe of humanoid aliens; a mere pair of glasses is enough to bamboozle Clark Kent's co-workers. When scifi counterfeits a human face poorly, with uncanny CGI (Leia in *Rogue One*) or dodgy make-up ('old' Peter Weyland in *Prometheus*) it can throw the audience out of the drama completely.

The face is also integral to establishing characters: In tales such as *Robocop* and *Ex Machina*, it is the face that allows viewers to connect with robot protagonists. Disfigurement, particularly in comic-book tales, is the defining instrument of The Joker, Darkman and Deadpool's transformation into something beyond human.

A technology that captures, maps and logs our faces, therefore, doesn't inspire the most optimistic visions. Like the mobile telephone, it narrows a writer's options: Superman's secret identity would hardly pass muster in the age of 'machine vision'.

We can only imagine how future marketeers will deploy this technology, accumulating facial data to build an ever-more-complete picture of consumers – and harangue them more efficiently. A face easily mapped is a face easily reproduced, and a future of adverts incorporating our own features cannot be far away: uncanny CGI doppelgangers projected online and in the street, showing us better version of ourselves, driving sports cars on mountain roads or brushing with new Gleemodent.

Who knows, society may fight back: we could set a story in a world where a new craze emerges in big cities: to wear 3D-printed masks of those that would steal and sell our likenesses; the Murdochs, Saatchis and Maybots of the future. One man has a particular fondness for masking up as the President. This draws winks and nods in the city, but on a trip to the countryside, where the practice is unknown, he is mistaken for the real thing and assassinated.

Governments would have something to say about masking up: there is something subversive about covering the face – as *Mr Robot* and *V for Vendetta* show – and governments could outlaw the mask, citing the notion that a revealed face is part of the social contract. But the fight could go on: new clans form, using jewellery, prosthetics and chin-length 'super-hippy' hair to confuse and scatter facial recognition scans. We could tell the tale of two super hippies who find love: unwilling to reveal their features, they show their affection by tying intricate knots in each other's locks.

What might the mapping and printing of faces mean for relationships? Could robots be masked up as lost or unrequited loves? Or used for more nefarious schemes? A story could follow a Hollywood actor who murders her actor husband. Attempting to cover her tracks, she masks up a robot to accompany her to premieres. She fears the robot's speech is too wooden to pass muster, so is stunned when his career takes off.

Whatever facial recognition takes us, we have to ask: if technology makes people hide, can it really be progress?

Jon Wallace is a science fiction author living in England. He is the author of *Barricade*, published by Gollancz

"A technology that maps our faces doesn't inspire optimistic visions"

Jon Wallace

Facial recognition could encourage us to mask our features

Motoring light years ahead

Aston Martin's DB11 feels as if it is in a different century to some of its predecessors. Chris Pickering **reports**

The DB11 marks the start of a brave new world for Aston Martin. Out goes the old VH platform that has underpinned most of the company's models since 2003. The glorious naturally aspirated V12 that stretches back to the DB7 is gone now too (at least from this part of the range). In comes a new bonded aluminium chassis, plus an all-new 5.2-litre V12 sporting pair of twin-scroll turbochargers.

This is also the first product of a tie-up with Daimler. Aston Martin is at pains to point out that the engine and chassis – and indeed most of the other parts – have been designed and produced in-house. Nonetheless, there are elements, such as the heating ventilation and cooling (HVAC) system and the back end of the infotainment system, which do come from the German giant.

It feels like stepping into a different century if you swing open the door of the DB11, having come from one of its predecessors. There's still an Aston Martin feel to the interior, with acres of leather and exquisite detailing, but it feels like it's jumped several rungs on the evolutionary ladder.

The instrument cluster now takes the form of an 11in TFT LCD display. Fear not if that sounds a bit synthetic – it works brilliantly, and you would swear the 3D-rendered rev counter was the real thing until it subtly changes colour as you switch drive modes. It's light years ahead of any other production Aston.

01

01/02 The DB11 is the first product to emanate from Aston Martin's tie-up with Daimler

The other thing that strikes you is how roomy it is inside. It's still a two-plus-two rather than a proper four-seater, but you can now get adults in the back. The front-seat accommodation is airier than other recent Astons.

To a certain degree that's down to the DB11's fundamental dimensions; it's barely any bigger than the outgoing DB9 overall, but it features a longer wheelbase that frees up space in the cabin. The use of hot-quenching to form some of the pressed aluminium chassis members has helped here too. This allows the structural elements to be sculpted into complex shapes that mould around the cabin space rather than intruding upon it.

Thanks to this new platform, the body in white is 39 per cent stiffer and 21kg lighter than that of the DB9. This, according to Aston Martin, means the total weight is around the same (officially quoted at 1,770kg), despite the addition of twin turbos, two extra gearbox ratios and a whole load of additional tech.

Thumb the keyless start button on the centre console and the DB11 fires with an indulgent flare of revs. At a stroke, it silences one of the key concerns about the switch to forced induction; this still sounds like a proper V12, albeit slightly different to the old naturally aspirated engine.

Performance is every bit as mighty as you'd expect. The new unit produces 600bhp and no less than 700Nm of torque. According to Aston Martin's figures, that translates to a 0-to-62mph time of 3.9 seconds and a top speed of

02

03

04

some 200mph. But it's the way that performance is delivered that defines the DB11.

There are vast reserves of torque from any speed in any gear – that much perhaps is to be expected from a large-capacity, turbocharged V12, but there's also a real appetite for revs and no discernible lag. All the while, those 12 cylinders deliver a rich, multi-tonal soundtrack. True, it's not quite as symphonic as the naturally aspirated V12 that still survives in the Vanquish and the Vantage, but it's a world away from the one-dimensional growl of most modern turbo engines.

The DB11 uses a variant of the ubiquitous ZF eight-speed torque converter automatic, which can be found in everything from Audis to Rolls-Royces. A degree of customisation was required in this instance to package it into the Aston's rear-mounted transaxle, but it was well worth it. The shifts are almost DSG-quick when you want them to be, but they're also smooth and unobtrusive when you're just gliding around.

03/04 Despite not being a proper four-seater, the DB11 is still roomy on the inside

I have to admit, we didn't spend much time going slowly in our brief date with the DB11, but when you do back off to a cruise the engine dies down to virtual silence. There's precious little wind or road noise either, which suggests long distances could be covered serenely if you wish.

Another interesting trick that's employed to boost the Aston's cruising credentials is cylinder deactivation. The big V12 is capable of shutting down six cylinders for extended periods at light loads. This helps the DB11 to achieve a claimed 24.8mpg on the combined cycle and 265g/km of CO_2 – respectable figures for a 200mph grand tourer.

With the Bilstein adaptive dampers in the softest of their three settings the ride is cosseting. They use a valve-type adjustment, as opposed to the magnetorheological systems found on some rivals, and the result is a very wide operating range. Switch to Sport or Sport Plus and the whole chassis takes on a sharper edge, without sacrificing too much of the comfort.

At 13:1, the steering ratio is significantly quicker than that of the DB9 (or even the Vantage). It's also Aston Martin's first electrically assisted system. There's a real delicacy and precision to its responses. For a car that does a pretty good impression of a luxury limo, the DB11 also feels remarkably lithe and alert.

At higher speeds, a host of clever aerodynamic devices help to keep things stable. The 'curlicue' vents down the sides, for instance, aren't just for show. These vent pressure build-up in the front wheel arches to prevent lift, but the undersides also have a wavey pattern to spin the turbulent air into vortices as it exits, reducing drag.

Part of the design brief was to have a very clean silhouette with no visible spoilers. Instead, the rear of the car has what Aston Martin terms an AeroBlade. This is a discrete slit in the boot lid, which draws high-pressure air from a pair of vents in the rear buttresses and fires it upwards to create downforce. Above 96mph, a small Gurney flap deploys to further increase the effect, but the bodywork remains an almost seamless piece of automotive sculpture.

The real beauty of the DB11, however, is its breadth of ability. Here is a car that can cruise in comfort, thrill on twisty roads and (just about) seat four. It fulfils the GT role perfectly. And for Aston Martin that's just the start. The same platform is set to spawn spin-offs, while a replacement for the smaller Vantage is also due next year. From what we've seen so far, the future looks very bright indeed.

The power of render at the push of a button

Autodesk and Microsoft team up for cloud rendering. Supplier: Autodesk

Microsoft and Autodesk are coming together to offer their customers a new approach in relation to scalable cloud rendering.

Built on Microsoft's Azure Batch platform, the approach will allow Autodesk users to submit their jobs for on-demand rendering directly via Autodesk Maya, Autodesk 3ds Max, and Arnold software.

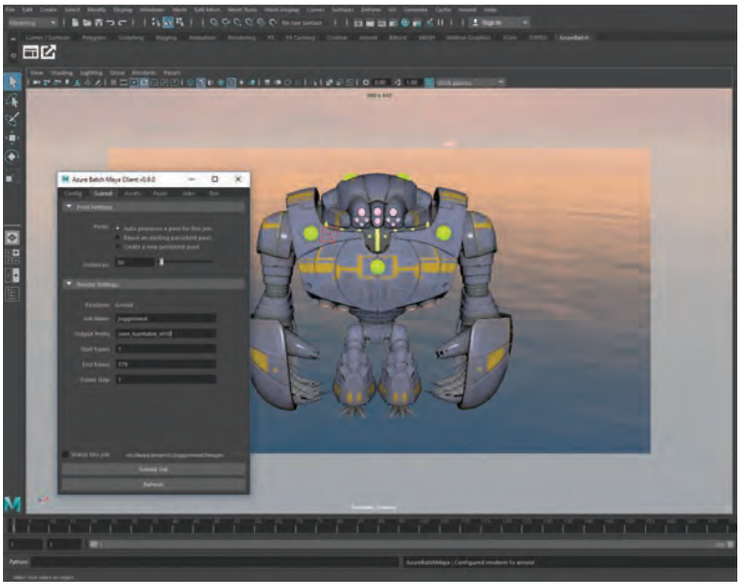
According to Autodesk, the pay-per-use service will enable customers to use Azure's cloud tools to scale rendering jobs with burst capacity as needed, efficiently manage costs, and eliminate the need for complex infrastructure and licence management.

"We know that the scalability and ease of use offered by cloud rendering is important to our customers across industries, and we're always looking for ways to help facilitate a smooth transition," said Chris Bradshaw, senior vice-president, Autodesk.

"Teaming with Microsoft Azure gives Autodesk users even more choice when it comes to leveraging the right cloud-based rendering platforms for their specific facility and project needs."

In addition, the Azure software development kit allows users to automate render workflows even within custom pipelines, and offers open-source plug-ins to integrate directly with Maya and 3ds Max. The overall product should provide Autodesk users with a wider variety of rendering options to select from based on their pipeline needs, data management, team size, timeline, and budget.

"With Autodesk Maya, 3ds Max, and Arnold integrated in Microsoft Azure Batch, designers, artists, and engineers can now focus on their creative projects rather than worrying about setting up, running, and managing infrastructure," said Corey Sanders, director of Compute at Microsoft Azure. "Everyone now has the power of a render farm with the push of a button."



Software moves swiftly on track

Performance data helps racing cars. Supplier: PTC

A new entrant to the motorsport market is using PTC software to collect performance data from the track and improve the design process.

Israeli start-up Griiip used PTC's Creo Product Insight during the design of the G1, an affordable, lightweight single-seater intended to open up motor racing to the masses. Designed in Tel Aviv but manufactured in Italy, the G1 weighs just 470kg with a driver on board, according Griiip. The cost-effective racer is aimed at competitors in the Formula 1000 class, where a 1000cc motorcycle engine is used to power a single-seat, open-wheel car.

Using a combination of onboard sensors, Creo Product Insight and PTC's Thingworx Internet of Things [IoT] platform, Griiip's designers have access to new levels of product and service data. This information can be fed back into the design process, helping Griiip make better decisions based on how the product is performing on the track.

"In our industry, it is critical to get things done faster, and products such as Creo Product Insight provide us with the tools to quickly bring to market new and exciting concepts in the world of motorsport racing," said Tamir Plachinsky, CEO of Griiip.

"We see huge value in the ability of Creo Product Insight to give our engineers real data from the track to enhance our design process."

Paul Sagar, PTC's vice-president of CAD product management, added: "PTC brings the power of the IoT and augmented reality [AR] to its CAD and PLM portfolio, actually supercharging the design process.

"Creo Product Insight enables designers to capture and connect real-world performance data with the original CAD model, thus allowing them to proactively design smart, connected products."

CAD is an act of Discovery for television programme makers

More time now spent on design work and less on rebuilding CAD models. Supplier: Ansys

Cameras have been an essential tool for Daniel Zatz and his team, who have flown across Alaska in helicopters to film television programmes for the Discovery Channel, National Geographic andthe BBC.

However, as industry trends change and camera technology evolves, HD resolution cameras are being superseded by 6k-8k resolution cameras. Camera stabilisation equipment also needs an upgrade, which is where Zatz's company, AgileCine Engineering, was born. It designs and implements camera stabilisation equipment upgrades that match the pace of camera and lens developments.

Cameras and the stabilisation system – the gimbal – are often connected, making singular upgrades impossible. Hence, a camera upgrade alone also requires an upgrade to the gimbal.

To design upgrades for the gimbals for content with 6k-8k resolution cameras, Zatz and his team initially worked with a low-cost CAD tool. However, this package had limited utility and after having tried a design concept they found themselves reworking models.

One of AgileCine's suppliers recommend Ansys SpaceClaim as a multi-purpose geometry tool. It discovered it could design more concepts more quickly while doing continuous design modifications without getting stuck in CAD theory. After starting SpaceClaim, Zatz realised parts were otherwise more refined, were generally optimised, and lighter weight. He attributed this to more time spent on design work and less on rebuilding CAD models.

Using Ansys SpaceClaim was a major boost for AgileCine. It took it three weeks to become design proficient and make progress on its projects. When it needed to improve a design, it found SpaceClaim infinitely flexible in making changes compared to other 3D tools.

Zatz and his team expected SpaceClaim to help with their general design requirements, but they realised several other pieces of functionality. In particular, they appreciated the lack of constraints when drawing 2D or 3D elements, and found modelling in a cross-section view vital to rapid design changes.

Getting ready for the Monaco race track

CADCAM helps reverse engineer obsolete parts for classic cars. Supplier: Solidworks

By harnessing scanning technology in conjunction with Solidworks, the ability to reverse engineer obsolete parts is helping to bring classic cars back to life. Dafyd Richards, founder of Redesign Sport (RSL) and his team have used technology from Solidworks reseller NT CADCAM to do exactly that for a classic 1952 Ferrari 225 with a faulty conrod.

The car was due to race at the Monaco Historic Grand Prix and RSL had eight weeks to get it ready for a customer in the US.

Richards said the piston was scanned on a Thursday morning using the Creaform Handyscan 700 scanner. The scan data was modelled in Geomagic Design X, then transferred live into Solidworks.

"By the Monday morning the 12 pistons went into production and we had the new pistons in our hands three weeks later," he said.

RSL also used Solidworks to remodel two distributors on the Ferrari that were causing problems with the ignition system. It remodelled every single component in the same way and sent all the parts out to different manufacturers.

"The parts had only ever been together on the screen in Solidworks, but when they all arrived they all fitted together perfectly the first time. The car drove magnificently in Monaco."

Richards added that RSL does make use of other brands of software, but always comes back to Solidworks.

"When I worked for a Porsche Supercup racing team, I'd seen the guys next door use Catia on their Le Mans LMP project and thought it would be painfully difficult for a CAD newbie such as me to come in and use it," he said. "I then discovered Solidworks 3D CAD, which was very easy and quick to learn. I have been using Geomagic Design X in real-world projects for the past couple of years and between the two products, RSL has achieved a huge amount of success."

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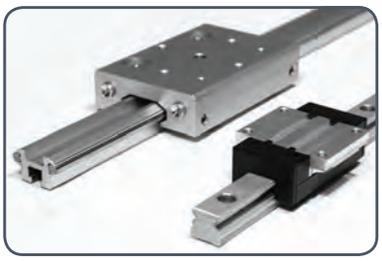

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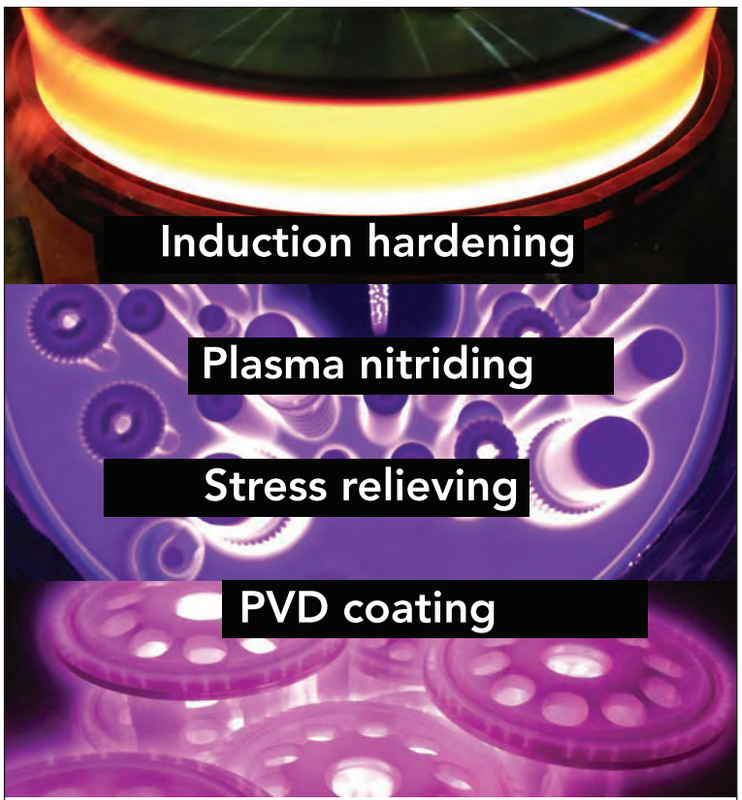

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Seeking to halve the costs of central vacuum supply

Rotary screw pumps produce less noise and emitted heat. Supplier: Atlas Copco

A new range of vacuum pumps from compressor specialist Atlas Copco could halve the cost of central vacuum supply, according to the company.

The GSD 3800-5400 VSD+ rotary screw pumps are claimed to produce less noise and emitted heat than conventional oil-sealed and dry vane vacuum pumps, while also requiring less maintenance as they do not use vanes that need to be replaced, while the intake filters and oil separators are designed to be replaced without the need to dismantle any piping.

The cost halving can be achieved by facilities upgrading existing vacuum systems or switching from using multiple decentralised pumps to a centralised system. "The payback period for a converted system is extremely short," said UK vacuum product manger Richard Oxley.

"The new units deliver more cubic metre per hour, per kilowatt than any other vacuum pump of comparable capacity."

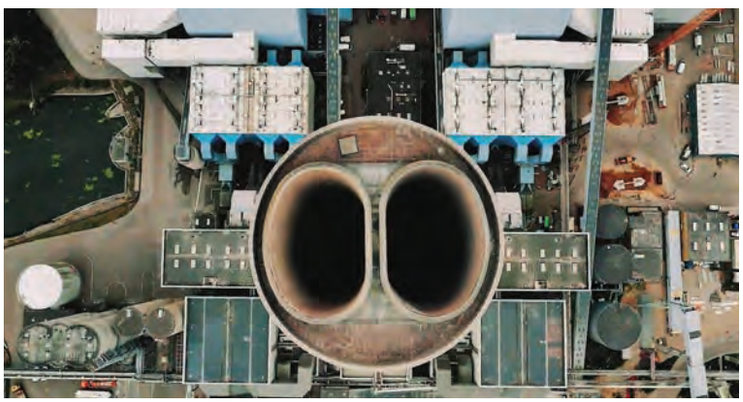
In excess of 90 per cent of large vacuum users could halve their costs, Oxley claimed. Atlas Copco is so sure of this that it is offering free vacuum energy audits to new customers and free 30-day trial periods for certain models. "To illustrate this, I recently visited a company in the food packaging industry whom we predicted could save in excess of £16,000 a year in energy costs by replacing its existing centralised system with a smaller number of GHS VSD+ pumps," he said. "Following this, an independent energy auditor was brought in to verify the results, while the pumps were on trial, who further upgraded the potential savings to the region of £20,000 a year."

The pumps are quipped with Elektronikon controllers that can be integrated into a process control system and with Smartlink remote monitoring systems and variable speed drives. The maximum flow rate for the range has been extended to 5004m³/hr.

Away from burning coals towards wood pellets

Peristaltic hose pumps assist in combined heat and power plant conversion. Supplier: Watson-Marlow

Bredel peristaltic hose pumps from Watson-Marlow are helping a Danish combined heat and power plant convert from burning coal to wood pellets. Part of an abrasives handling system, the pumps handle a high-density inhomogeneous slurry that contains rough particles.



The plant, operated by Dong Energy at Studstrup, produces fly ash that is mixed with 35 per cent water to bind alkali residues, preventing them from damaging boiler walls and poisoning a deNOx catalyst. Normally, such slurries are handled by large hydraulic pumps, but the potential for high hose wear led Dong to investigate other options. "Before plant construction could commence, a test facility had to be built to determine the viscosity of the ash slurry, as well as measure the pressure drop of the pipes at a given water percentage so that pumps and pipe runs could be dimensioned appropriately," said Edo van der Meulen training and application manager at Watson-Marlow Bredel BV in the Netherlands. "From this, we calculated that the mixing plant could be sized to 50m³/h, with the supporting dosing system to feed in at a maximum of 280m³ per day. Watson-Marlow participated fully in the dimensioning of the pumps and with the pressure calculations.

"The effect of abrasiveness on hose life is low; the effect of factors such as dry solid content and pump speed is much higher. At Studstrup, the dry solids content of the fly ash entering the system is controlled automatically – when it exceeds the limit at which the slurry can be successfully pumped, a Bredel 40 is activated to add water until the B100 [used to transfer the prepared slurry from a buffer tank to the storage tanks] is able to pump again. As for pump speed, this has an almost linear effect on hose life: half the speed is double the hose life."

Advanced Manufacturing

New ultrasonic probe checks hot-dip kettles

Galvanised steel is used in numerous sectors but the zinc coating that gives the metal alloy its longevity has to be heated to around 450°C in kettles that require periodic inspection.

Hot-dip galvanising involves immersing chemically cleaned steel products into zinc kettles that must be checked for rates of corrosion throughout the equipment.

Those corrosion rates vary depending on volume, dip size and the amount of production at each plant, and previous monitoring techniques have included draining the molten zinc from the kettle into another device, or leaving the kettle to cool before physically sampling its surface.

Now, Zinco UK is about to introduce an ultrasonic probe that monitors the kettles in situ. The Hereford-based company and Sonemat have signed an agreement to use the ultrasonic probe technology developed from research that was first conducted at Warwick University.

In use, the probe is mounted on a steel framework that sits on top of the hot-dip galvanising kettle, said David Watkins, managing director of Zinco UK. It is inserted into the zinc by either a vertical motor drive or manual operation.

Watkins added that the heart of the probe contains a novel high-temperature ultrasonic sensor that is capable of launching ultrasonic waves into and from the molten zinc. All the internal components of the ultrasonic transducer inside the sensor are designed to survive temperatures of 450°C without any cooling.

"Typically [for] an inspection of average-sized galvanising plant, the probe would be submerged into the zinc for approximately six hours," he said.

Watkins added that the probe has a design life of more than 30 inspections as long as it is properly maintained and not subjected to large thermal shocks.

The probe could serve 30 per cent of the global market

Laser-powder additive is going large

The additive manufacturing division of GE is developing what it claims will be the world's largest laser-powder additive manufacturing machine.

Specially tailored for the aerospace industry, the machine will be able to build jet engine structural components and parts for single-aisle aircraft in a build envelope of 1m³.

An initial demonstrator machine – called ATLAS – will be unveiled in November at the Formnext Show in Frankfurt, Germany. According to the firm, this will be "metre class" in at least two directions.

The machine's production version – which will be metre class in all directions – will, it is claimed, boast feature resolution and build-rate speeds equal to or better than today's additive machines and will be able to use multiple materials, including non-reactive and reactive materials such as aluminium and titanium.

The system will be based on technology developed by Concept Laser, a German additive specialist. GE is targeting first deliveries of the machine in late 2018.

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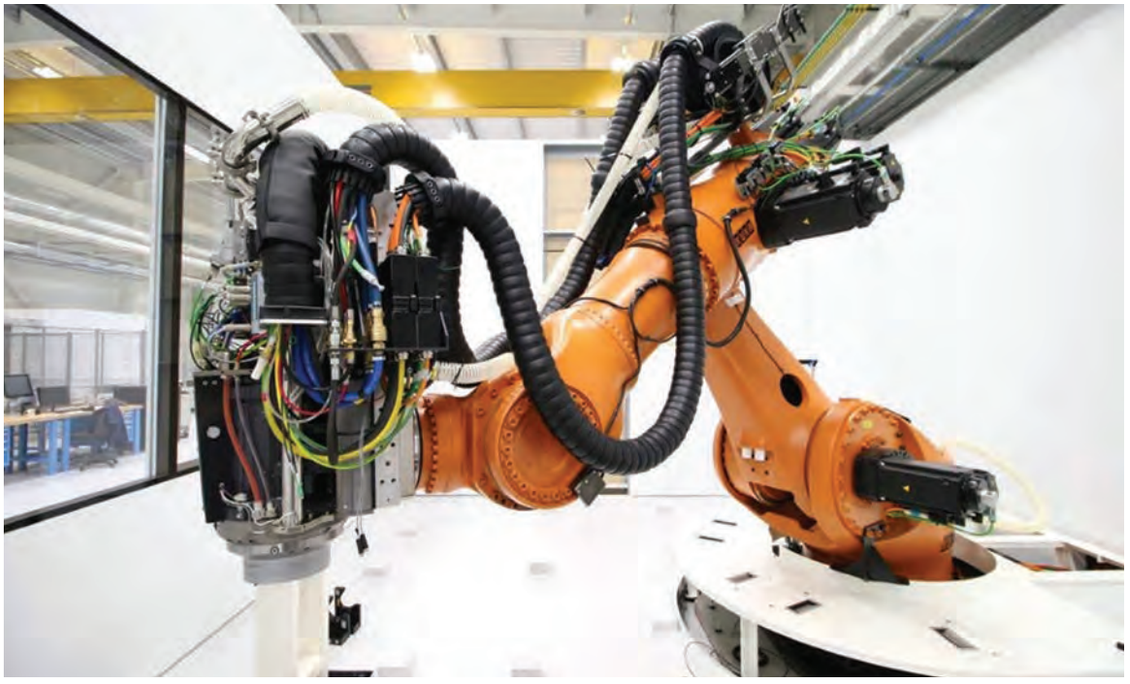

Researchers modified a Kuka Titan robot to machine parts with an accuracy below 100µm, in an £850,000 project

One of the world's most accurate large-volume machining robots is being developed in the UK.

The robotic milling system could remove some of the workload of expensive machine tools, alleviating bottlenecks on the production line.

Researchers at the University of Sheffield Advanced Manufacturing Research Centre (AMRC) with Boeing, with support from the Aerospace Technology Initiative, have modified a Kuka Titan robot to develop the robotic milling system, in an £850,000 project.

The robot can machine parts with an accuracy of below 100µm. This is below the accuracies achievable with high-end machine tools, but a significant improvement on existing robots, according to Chris Greaves, operations manager of the AMRC's Integrated Manufacturing Group at Factory 2050.

"We see a big benefit in having a large flexible tool such as a robot being able to do accurate milling," said Greaves. "Machine centres are often bottlenecks in factories. You might have a £10m machine tool with a large working area and for a lot of its time it is doing roughing cuts."

Instead, the robot could undertake rough cuts and semi-finishing work while the machine tool is left to carry out any high-surface finishing, he added.

To improve the accuracy of the robot, the researchers replaced the original motor encoders, which tell the machine where it is in space, with new rotary encoders, developed by Renishaw, at each joint.

"An inherent issue with robots is that they measure their position based on the position of their motors, not their joints, so you can have quite a large stack-up of errors," said Greaves.

With the encoders fitted to its joints, the robot is able to measure its position more accurately.

The technology was developed with Electroimpact and could result in accurate, stiff-but-flexible robots capable of machining metallic and composite structures.

The system could also reduce the need for expensive specialised multi-axis machine tools, and could be used in aircraft manufacturing as well as the automotive, defence and marine industries.

The robot has been installed at the AMRC and the team plan to carry out research over the summer to demonstrate that it can perform as they expect.

MANUFACTURING

Rimstock gets £12.4m to build new plant

CYBG is funding the alloy wheel-maker's project

JASON FORD REPORTS

A British manufacturer of premium alloy wheels is to build a brand-new manufacturing plant following receipt of a £12.4m funding package.

West Midlands-based Rimstock designs and manufactures alloy wheels for several marques worldwide, and supplies over 40 global motorsport series under its Team Dynamics brand.

The finance package agreed with Clydesdale and Yorkshire Banks (CYBG) will see the company develop a new 100,000ft^2 manufacturing plant, which has enabled Rimstock to continue its expansion of its West Bromwich base. Further funding from CYBG will be invested in new machinery and equipment.

Land for the new plant was bought from the local council and the plant is expected to produce new jobs in the area.

Kevin Rimmer, head of manufacturing at CYBG, told *The Engineer* that Rimstock was "struggling with its existing bank" when it was taken on board as a customer during the downturn in 2008. According to Rimmer, the decision was based on the bank's understanding of the automotive sector and confidence in its overall recovery.

"Rimstock is… expanding rapidly with the growth we're seeing from OEMs in the sector," he said. "So we've been funding the acquisition of a new site for it, and we're able to do that based on our understanding of the nominations it's got with the larger OEMs. We've probably been able to support it at a higher leverage than some of the other banks would have done…simply because we understand the mechanics of the industry.

"They're delighted with what we've done, they've continued to grow and we see them as a good example of the type of business that's doing well in automotive."

CYBG will be lending "a minimum of £6bn" to UK SMEs from 2017 to 2019.

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Additive at the final frontier

Johannes Gumpinger, advanced manufacturing processes engineer, ESA, on the possibilities of additive manufacturing in and for space

Discovery has always been a huge driver of space exploration and together with peaceful collaboration is a key element of the European Space Agency's (ESA's) mission. This thirst for knowledge and co-operation means that the ESA is striving to find the most effective ways to improve its missions and remain a key contributor to advances in science and technology.

Space programmes such as NASA, ESA and private companies are already investing in and experimenting with the logistics of sustained space exploration – taking steps to make the International Space Station (ISS) and future space habitats more self-sufficient.

Additive manufacturing (AM) is already playing a key role in this – through its current applications on Earth and on board the ISS, its near-term possibilities for further use on orbit, through to the fruition of current research into its future use on other planets. AM's ability to produce small volumes of customised, technical parts quickly and efficiently lends itself to the space industry – which is why ESA has been developing and using AM technologies for the best part of 10 years to produce tools and equipment for use in space.

While controlling the entire AM end-to-end process remains challenging, using AM to produce hardware on Earth for use in space is still essential. AM's design freedom enables significant increases in performance, combined with reduced lead times and costs, which make it a favourite for engineers – especially as the technology continues to advance, making way for achieving higher build rates, producing larger parts and using a more extensive range of materials. The technology in general is growing significantly, by up to 40 per cent each year.

These advances in the technology support further discovery, enabling the manufacture of structures that were not viable with traditional production methods up to now.

For example, we are currently working with a German company using AM to demonstrate the technology to build an optical bench for an X-ray telescope to be used in ESA's Athena mission. The optical bench for this activity has a diameter of 3m, is 30cm high and is assumed to be able to host up to about 1,000 mirror modules, which – once it is complete and launched into space – will observe the hot and energetic universe in the X-ray band.

Ultimately, we would like to be able to produce such parts in orbit – e.g. on board the ISS – to save on raw materials and launch costs. However, there are still hurdles to overcome to make this happen, as AM techniques used on Earth today are not necessarily deployable under specific space conditions, including microgravity.

That isn't to say that additive manufacturing isn't already proving useful on orbit. A 3D printer is currently in operation on the ISS for polymers, which is being used to produce functioning parts for the station. Ongoing technology development activities are also taking place to establish metal additive manufacturing equipment on board.

Once this challenge is mastered, the crew of the ISS – and future space habitats – will be able to recycle polymers and metallic materials brought during the mission to produce and repair the tools and equipment they need to keep things working without needing to ship them from Earth.

This will not only result in entirely enhanced mission logistics on the ISS, for example, but may also revolutionise the way in which spacecraft structures are designed today, as the structures will not need to withstand the launch process. Hence, they could be lighter and the manufacture would consume significantly less material. Extensive R&D is taking place to overcome the main barriers for printing metal parts in space, including microgravity and the limited availability of energy. The kind of raw material to be used may be substantially limited, as powders, for example, cannot easily be contained in the machine under microgravity, and would therefore pose a significant health hazard for the astronauts.

> "Additive manufacturing is a driving force for space engineering – on Earth, orbit and other planets"
>
> Johannes Gumpinger

While this is a longer-term goal that will require substantial funding, experiments are already being conducted on Earth, proving its feasibility as a concept. Within an R&D activity, a chemical AM process was used to transform moon regolith simulant, layer by layer, into a solid 1.5-ton demonstrator structural element.

Whether it's helping build the foundations of a telescope due to be launched from Earth in 2028 or building life-sustaining structures on Mars, AM is a driving force for space engineering – on Earth, on orbit and on other planets.

Future space habitats will be able to recycle polymers and metallic materials brought during the mission

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Facing up to the 5-axis challenge

Another supplier of machine tools to SMEs introduces a 5-axis machining centre – perhaps a sign of supply-chain focus on complex, precision components. Mike Excell reports

Increasingly, successful companies at every stage in the manufacturing supply chain for machined parts recognise the need for equipment that can deliver technically complex solutions. In this context, 5-axis machining capability is becoming ever more attractive to SMEs. With the aim of allowing more of them to enter the growing 5-axis market, XYZ Machine Tools has now added a full simultaneous 5-axis, gantry-style, machine with a trunnion table machining centre to its range – The UMC-5X 'Challenger'.

The XYZ UMC-5X is based on a compact, gantry-style, trunnion design that maximises the front-loading working area while maintaining a relatively small footprint. Its construction employs solid meehanite castings to create a rigid platform that allows high-speed, precise machining of complex shapes and forms across a wide variety of materials. A key feature is that when the table is tilted 90° towards the rear (i.e. component facing forward), there remains 500mm of Y axis travel forward of the table surface. This is said to be greater than other machines that quote the same axis travels, and allows larger workpieces to be machined. Although new to the XYZ range, it is a well-established design with more than 200 machines installed in Russia, Germany, Spain, France and Italy, and over 30 toolroom installations in Portugal alone.

01 Internal, external rotors and compressor casing machined on DMG Mori HSC 20 linear at Vert Rotors

02 Okuma MU-6300V 5-axis, vertical-spindle mill-turn at Bromford Industries

XYZ offers the machine with the Siemens 840DSL control as standard or Heidenhain iTNC640 HSCI; both have Traori/Kinematic options and fast block processing capabilities, and integrate Smart Machining Technology (SMT) – the key elements of which are Tool-Tip Positioning Control (TTPC), Spindle Vibration Supervision (SVS), Metal Removal Rate Optimisation (MMRO) and Axial Accuracy Control (AAC).

"The machine is a perfect fit with our existing range; it combines excellent value for money with extremely high specifications, which we know will make it attractive to XYZ customers," said managing director Nigel Atherton. "We took our time in sourcing the UMC-5X in order to be confident that we had the right solution to 5-axis machining to meet the needs of a wide variety of customers."


01

Falling into the centre ground is Durham-based Altec Engineering. Founded in 1978, it now turns over £15.5m and employs nearly 200 people. "Over the last few years the business has really transformed and diversified into a number of different markets, yet we've tried to stay true to the company's original ethos of high-quality production engineering," said Paul Lackenby, group business development director.

The company's machine shop manufactures ultra-high precision, low-volume prototype components for the aerospace, defence, oil and gas, and nuclear industries. In the early years the focus was on entry-level machines, added Lackenby. "However, as the business grew, customers were exploring our ability to handle more demanding projects, chiefly in the defence, and oil and gas markets, which exposed the limitations of those machines – particularly the physical torque and the lack of software functionality.

"One of the biggest limitations we found with our original machines was the need to purchase third-party control systems; we felt we would be better off choosing a supplier that had both the machining and design capabilities in one." Altec's first foray into 5-axis territory strategy was a Mazak VTC 800 30/SR, purchased for a defence contract. It was enhanced with added high-pressure coolant, extended tool magazine, and remote wireless probing. The project entailed manufacturing high-accuracy and high-tolerance transmission equipment for the Challenger II battle tank. "That was one of the hardest jobs I've ever production engineered and without the VTC we wouldn't have had the capability to do the work, and ultimately wouldn't have won the contract," said Lackenby.

The addition of 5-axis machining reinforced the company's credentials as precision machining specialists, and sparked further investment. "The VTC was running flat out 24/7, we were in danger of turning down work for other customers, and therefore decided to invest in another Mazak 5-axis machining centre: a Variaxis i-700 twin pallet multi-tasking machine tool, complete with the new Mazatrol SmoothX control – which brought added benefits: "Its Intelligent Pocket Milling has resulted in much higher accuracy cuts at 90° angles, due to the machine's ability to decelerate the tool into the corner and speed up afterwards. There's much less pressure on the tool and the machine can work to tighter tolerances – which is absolutely crucial for the aerospace sector."

Olly Dmitriev, CEO of Edinburgh-based Vert Rotors UK, would no doubt concur with Lackenby's take on the advantages of 5-axis technology. The company produces compact, high-pressure and low-vibration gas compressors, designed for aerospace, medical and other applications where vibration and noise are not acceptable, and dimensions and weight are mission-critical. A new type of oil-free screw compressor developed by Vert Rotors has proved to be 35 per cent more energy efficient than dry

"There's much less pressure on the tool and the machine can work to tighter tolerances – absolutely crucial for the aerospace sector"

Paul Lackenby, Altec Engineering

oil-free machines. There is no stator in the design, which is common in rotary twin-shaft compressors and that allows the gas being compressed to leak back; Vert's compressors have only a pair of male and female screws with virtually no clearance between them, prompting the need for high-accuracy 5-axis machining.

"Our rotary design is virtually vibration-free," said Dmitriev, "vital where the compressor is located next to delicate sensors." The company's latest products use small, high-accuracy rotors that need to be machined in 5-axis mode. "We chose the DMG Mori HSC 20 linear second generation," he added. "The machine has linear drives and scales unaffected by backlash, and the composite granite frame gives exceptional temperature stability making it possible to achieve 5µm accuracy and very high-quality surface finish of Ra 0.15µm." Other factors important in the choice of machine included the minimal headroom and floor preparation required for installation.

Meanwhile Bromford Industries, a specialist manufacturer of aero engine and landing gear components is currently investing £7m in nine 5-axis machines – Okuma MU-6300V mill-turn centres from UK agent NCMT – in its Birmingham factory. The Japanese-built, 5-axis, vertical-spindle machines are ideally suited to volume production of nickel alloy aero engine parts to tight tolerances. Seven of the machines are already producing components, with the remaining two due for delivery in the fourth quarter of 2017. They form the major share of a £10m investment at the Birmingham plant that includes tooling, automation, metrology equipment and CADCAM software.

Mike Tew, operations director at Bromford Industries, said: "The Okuma VMCs were selected due to their perceived quality, which has subsequently been demonstrated in production. Our aerospace supply programmes are long term and to fulfil them we need machine tools that maintain top levels of accuracy for extended periods, especially as they are running 24/7." Bromford plans to install an automated storage and retrieval system from Fastems, that has already been designed by NCMT to link seven of the MU-6300Vs to form a flexible manufacturing system.

Investing in technology requires a combination of expertise, perspicacity… and perhaps an element of bravery. A move to 5-axis machining on critical parts is a common thread running through the stories of the numerous companies that tick all these boxes.

03

04

03 Altec's Paul Lackenby with the Mazak Variaxis i-700 twin-pallet multi-tasking machine tool

04 XYZ'S newly introduced UMC-5X Challenger

"We need machine tools that maintain top levels of accuracy for extended periods"

Mike Tew, Bromford Industries

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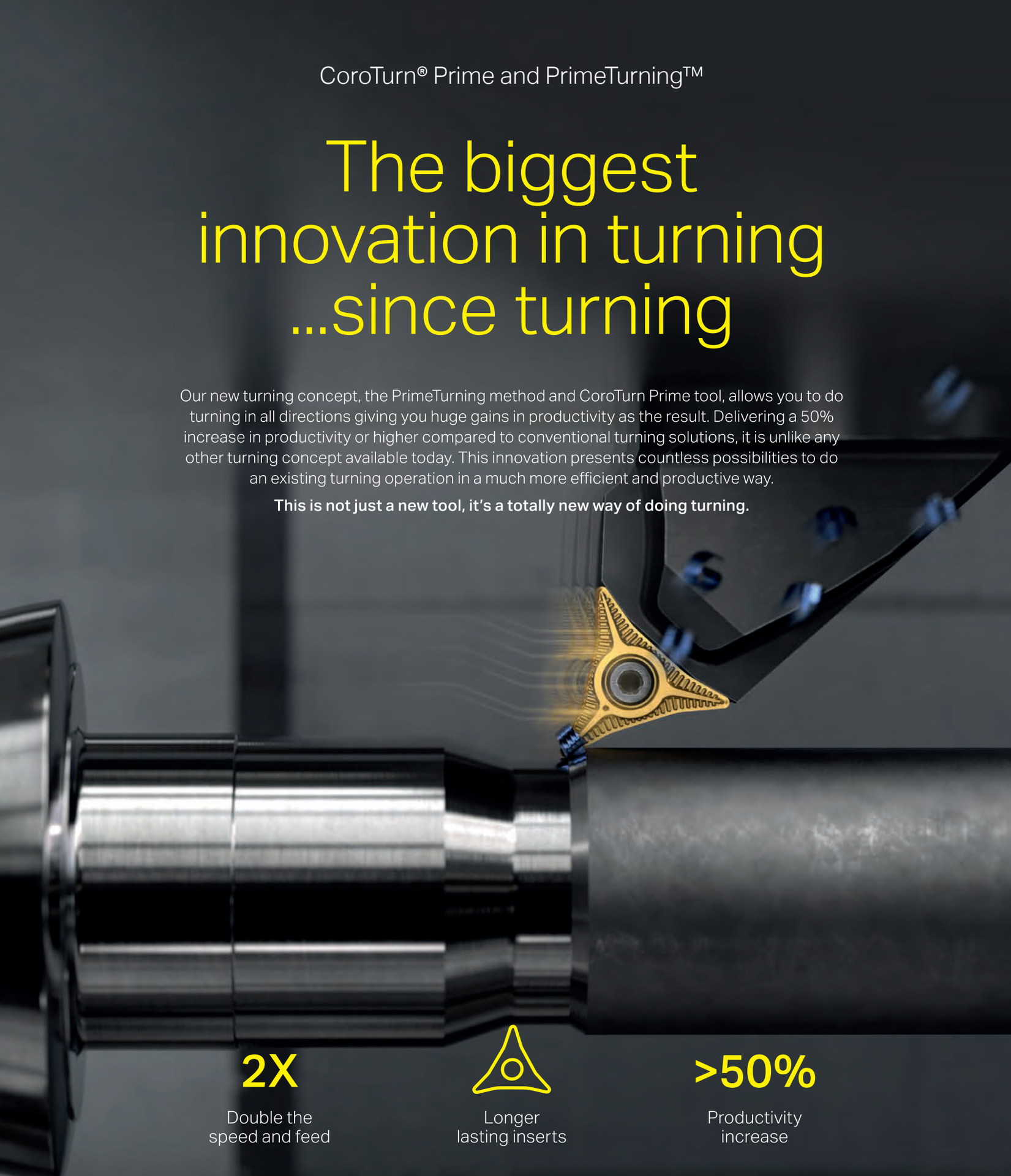

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Making haste

Speedy development time matches a speedy performance on the road for Norton's latest motorcycles. Mike Farish **reports**

Speed is what Norton motorcycles are all about and the latest machines from the iconic British company that now operates from premises in and around a stately home Donington Hall in Leicestershire certainly deliver on that.

Edging past 200mph is no problem for either the Norton V4 SS or V4 RR machines introduced to the public at the Motorcycle Live event at the NEC in Birmingham at the end of October last year.

The reasons include the powertrain for both bikes – the company's new 1,200cc, 200bhp V4 engine – and a weight of just 179kg, making them lighter than the TT machines from which they are derived.

Other aspects of their specifications are equally impressive. The chassis of the V4 SS, for instance, features a 3.1kg swing arm CNC machined down from a billet originally weighing 70kg, while both machines feature a Kevlar-reinforced carbon-fibre fuel tank cleverly positioned under the seat in a way that both helps provide a narrow profile overall and enables its underside to form the upper part of the airbox.

In fact, the machines are siblings differentiated from each other by their respective materials, production processes – machining for the SS and casting for the RR – and features such as the titanium exhaust system for the SS rather than their fundamental geometries or systems, such as suspensions or electronics, which are identical.

Nevertheless when the bikes are released to customers – probably towards the end of 2017 – those differences will show up sharply on their price tags. The SS, which is available only in a limited edition of 200 that is already sold out, will cost £44,000 while the RR, which will be a series production machine, will cost a comparatively modest £28,000.

While the performance of both machines puts them firmly in the 'superbike' category, there is another way in which speed is the dominant factor in the equation: namely the short timespan in which the new machines were developed.

According to Simon Skinner, head of design for the company, the bikes went from a blank sheet of paper to public demonstrations in just 12 months. Indeed, the actual design time, he said, was much less – "six to seven months" – because the company still had to go to tooling and make the first pre-production machines.

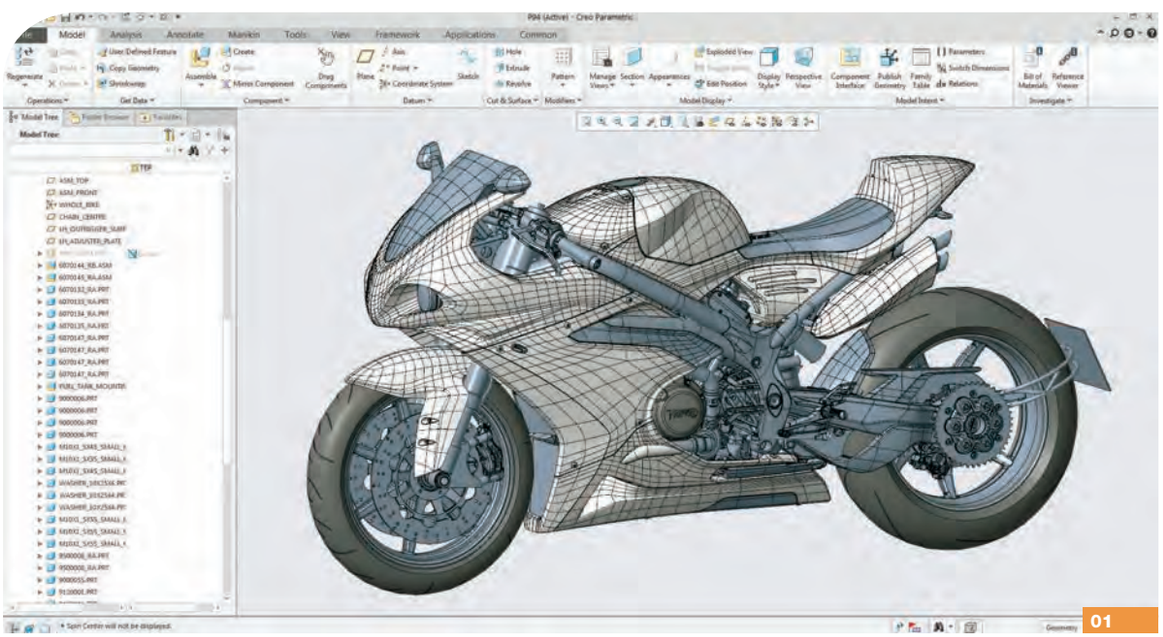
01/02/03
Norton's latest superbikes went from a blank sheet of paper to the road in just 12 months

Moreover, this was all achieved with minimal resources in terms of people: a team of barely a dozen other people within the company split 50-50 between design and "engineering" in other words translating the geometry into manufacturing processes.

So how was this accomplished? Several factors were involved, explained Skinner, one of which was that the project entirely dispensed with physical modelling. Instead the project went "straight to tooling" machined from aluminium in just a couple of further months, which was "right first time" and did not require any reworking.

This also had implications for costs as well as timings. "A whole suite of tooling for the carbon-fibre bodywork can be produced in a couple of months and costs £10,000," he said. In contrast, the outlay for a clay model might well run into six figures and even then "might not be right". As it is, he confirmed, "everything is first go".

Interestingly, Skinner added that the rapid prototyping techniques that might seem to suggest themselves as ideal tools in this scenario would, in fact, be of little use because



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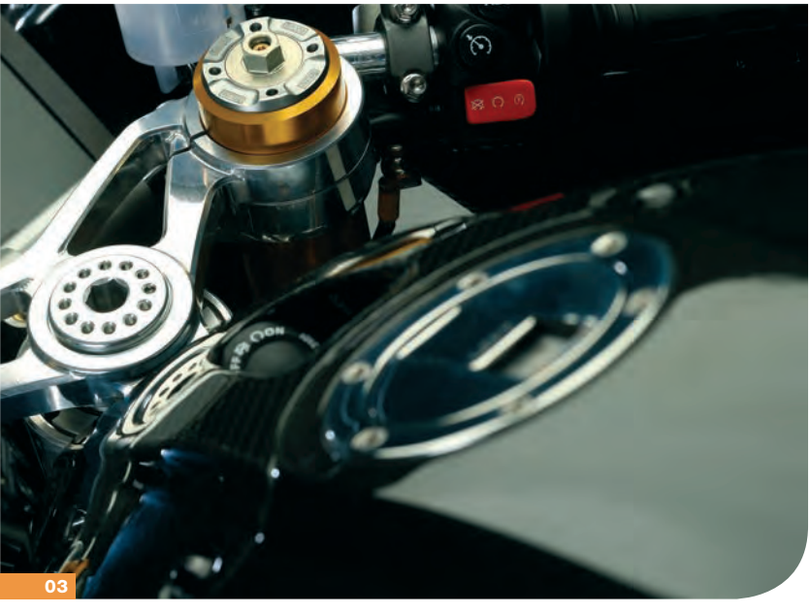

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the carbon-fibre shapes in the final bikes cannot be replicated easily in the polymer materials used by additive processes. He conceded that they could be used to see what an intended injection-moulded part might look like but "that would cost £30,000 to tool up and have a 16-week lead time".

An equally fundamental role was played by the design system used for the project: PTC's Creo package and specifically its Freestyle module for creating surface models. "It completely changed the way we did things," said Skinner. "If we had used conventional design and surfacing techniques we would only have been taking the bikes to the NEC this year." He explained that the module effectively allowed him "to play with ideas and sketch them", and then create pure surface data by simply dragging points around on the screen. The procedure was so straightforward that he actually did a lot of the work involved at home "at the dining-room table" using a laptop device, after which the data was turned into full 3D modelling information back at base in the main Creo system.

Although the engine design was outsourced to engineering consultancy Ricardo, Skinner pointed out the particular operation is located "just 15 minutes away", which facilitated very close cooperation. "I was in there every day," he said. "We packaged the engine alongside the chassis so that a bike the size of a 600cc bike has a 1,200cc engine."

Another factor that was instrumental in achieving the compressed development timescale was the structure and internal communications of the company which, said Skinner, have been revitalised by its current ownership.

Despite having a heritage that dates back to 1898, by 2008 the company had become little more than a name and some residual intellectual property when it was bought by entrepreneur and now chief executive Stuart Garner.

Early the following year Skinner became the first recruit. Garner and Skinner worked closely together without any supervisory board so that key decision-making is the result of their direct personal interaction. In fact, added Skinner, where product design issues are concerned "Stuart often just leaves it to me".

Since then the company has, Skinner said, come to employ some 130 people and built around 2,000 machines – mainly its Commando and Dominator road bikes, although it also now regularly goes to the Isle of Man TT races with bikes that carry an 'SG' title. But those racing forays are not an add-on to its mainstream design and manufacturing operations but a "key development tool".

As such he confirmed that the company's 2016 TT bike the SG5 provided a lot of input in the form of know-how about such factors as weight distribution and aerodynamics to the SS and RR machines but stressed that the latter are nevertheless distinct new machines.

The total cost for the development project for the SS and RR machines was £7m, of which £4m came from UK government grant support, although Skinner is keen to point out the public money went into the "supply chain" rather than Norton. Appropriately the new machines are "80 per cent British by part count".

Right now the company is carrying out testing on pre-production machines and gearing up to start production through the commissioning of new CNC machining facilities. Two modified SS machines will be racing as SG6 bikes at this year's TT from 27 May to 9 June. Undoubtedly the experience will feed into future development projects for which the underlying objective will, Skinner confirmed, be to produce motorcycles that aim first of all to sustain a reputation: "We want to make bikes that are true to Norton and then see how many we can sell."

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Mass-market 3D printing

A cloud-operated multi-cell manufacturing concept offers a glimpse of the future of 3D printing. Mike Farish reports

The various additive manufacturing techniques that have been developed over the past couple of decades or more are now not just well-established tools for their original application area of rapid prototyping, but also for actual production. But in that latter role the take-up of the technology has always been impeded by a number of persistent factors apart from the intrinsic slowness of the fabrication technique itself. These include the fact that the machines tend to be bulky standalone pieces of equipment and that they require manual unloading of finished parts.

But what if those inhibiting factors could be largely abolished? What if additive manufacturing could be carried out by a bank of appropriate machines stacked side by side or on top of each other to create a simultaneous multi-cell production capability for either identical or different parts? What if those cells could operate on an extended unattended basis because they had both a co-located stock of raw material to draw on and could unload finished parts automatically? Also, what if they possessed an integral self-scheduling capability so that manufacturing could be automatically routed to the first available cell? And what if that overall control could be affected by a web-based cloud computing system so that the machines could operate in almost any location, irrespective of where they were managed, to serve local markets and thus greatly reduce the costs of transporting finished goods?

What you would then have, observes Stratasys' Roger Kelesoglu, would be a "no-tooling, zero inventory" and therefore economically viable means of manufacturing parts in volumes much larger than is normally associated with additive techniques. And intriguingly, according to Kelesoglu, who is director of sales enablement for the US-based additive specialist, this prospect is no way fanciful. Instead, it is precisely what is embodied in a technology demonstrator unit unveiled by the company within the past couple of months.

At first sight, the Stratasys Continuous Build 3D Demonstrator looks almost like a large vending machine composed, as it is, of multiple stacked rectangular units, each of which has a plastic basket in front of it to catch ejected parts. But each of the units is, in fact, an additive manufacturing device employing the fused deposition modelling (FDM) technique in which objects are built layer-by-layer using a liquid polymer extruded through a nozzle.

Surprisingly, perhaps, Kelesoglu said that actual development of the Demonstrator did not take too long because it is effectively a combination of existing state-of-the-art technologies upgraded to provide the machine with its 'smart', autonomous characteristics. Indeed, he pointed out that the Demonstrator's software-based capabilities in areas such as "load balancing, scheduling and print optimisation" are every bit as crucial as the more visible enhancements within the cells themselves. "When you send a print order to the machine, you are not sending it to a particular cell but to a virtual print capacity," he explained. Interestingly, he adds that those capabilities are derived from Stratasys' operation of its bureau services in which it uses its own equipment to make parts for customers.

Perhaps the most obvious of the more physical enhancements to existing additive technology is the entirely novel self-unloading capability that obviates the need for a human operator to remove completed parts before work can start on making a new one. This innovation involves using a roll of plastic sheeting as a base upon which new parts are fabricated. When a part is finished, the sheet is cut and the section on which the part is standing ejected into the basket. A new section is then unrolled so that a subsequent build-process can commence immediately.

The print cells themselves, Kelesoglu added, use the current "highest-end" version of company's FDM **>>**

01 Fathom began operating its six-cell Demonstrator earlier this year

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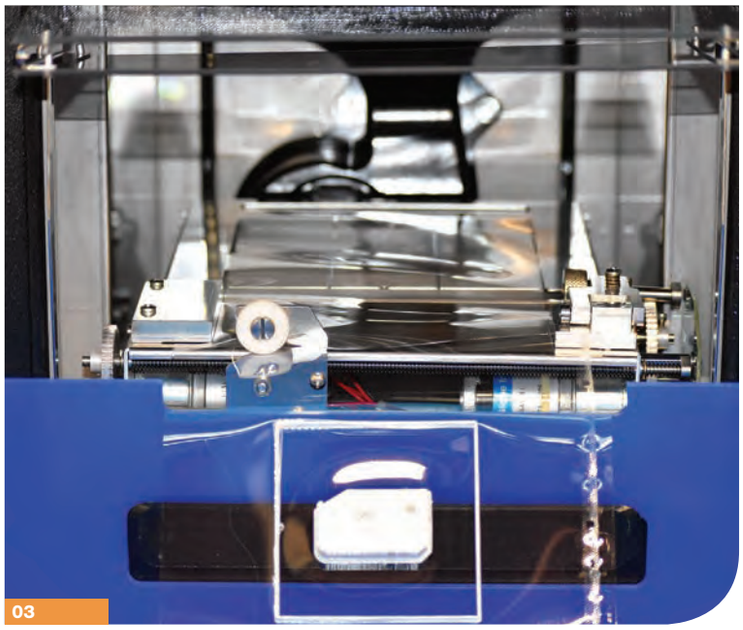

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02 A key attribute of Demonstrator is its ability to increase volume of parts made

03 Demonstrator can make design changes even if production has started

>> technology to manufacture parts in ABS material, although there is no reason why other materials could not just as easily be used. Kelesoglu indicated that one multi-cell machine could quite feasibly offer print options in a range of materials with different cells supported by their own dedicated reservoir of raw material. Similarly, though, the current configuration of the machine allows for the on-board storage of enough raw material to support "six days" of unattended operation that again could easily be altered according to requirements. But whatever the amount involved, an "inventory of materials" is, as Kelesoglu observed, always cheaper to maintain than an "inventory of finished parts".

Stratasys doesn't yet have a timetable to bring the Continuous Build capability to the market as a commercial product. But Kelesoglu confirmed that it is working "with some urgency" to develop the concept in cooperation with a small number of real users.

One of those operations already exploring the potential of the Demonstrator is FATHOM, an advanced manufacturing and consultancy outfit operating from Oakland, California, and Seattle on the US West Coast. Co-founder and principal Rich Stump said that the company has been operating a six-cell Demonstrator at Oakland since early this year, in addition to its existing battery of over 35 standalone additive machines of various types.

Stump explained that the fundamental objective is to help push additive techniques much further "into production, not just for our company but the industry as a whole". As such, he confirmed Kelesoglu's belief that a key attribute of the Demonstrator is its ability to increase the volume of parts that can be made economically and efficiently without the need to invest in hard tooling. On that count he is quite specific, stating that whereas previously anything over 500 parts made tooling necessary – a relatively low number that would necessarily increase unit cost quite significantly when the capital investment in the tooling was amortised over it – that figure has now increased to around 2,000.

But Stump also made it plain that more than just cost is involved and that the Demonstrator concept also provides a number of other advantages. Perhaps the most important of those is "agility", which he defines as the ability to make design changes in a part once production has started – something likely to prove impractical with hard tooling without scrapping it completely and making a new investment. Moreover, such changes can be put into effect in just a few "days", whereas creating new mould tooling would necessarily be a matter of "weeks".

Stump also confirmed that the Demonstrator's integral scheduling capability greatly simplifies the management of the manufacturing process. "You just input the design file, tell it how many parts you want to make and then the software allocates them to the different cells," he said.

Stump added that the machine has already been used to help fulfil real commercial contracts, including in the fabrication of parts for a very unusual and arduous application – a monitoring device attached to Great White Sharks by a team from the Monterey Bay Aquarium Research Institute to track the animals' behaviour at sea down to depths of 250m.

In the immediate term, further development work to increase the range of materials that can be used and the current build envelope of 5 x 5 x 5in will be necessary, said Stump. But his answer to the question of whether the basic concept underlying the Demonstrator has been validated is emphatic and unambiguous: "Yes, certainly."

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More than a sum of its parts

Platform has potential to link part buyers to micro-factories. Supplier: Siemens

Siemens has revealed plans for an online collaborative platform designed to bring on-demand product design and 3D printing production to the global manufacturing industry.

The company claims that its so-called part manufacturing platform, which was announced at Hanover Messe 2017, will provide an environment capable of connecting all members of the global manufacturing community in order to maximise resource utilisation and access additive manufacturing expertise.

For instance, by linking part buyers to micro-factories, the platform would enable members to 3D print production parts on-demand where needed across the world.

In addition, the platform will include collaborative capabilities to help streamline the collaborative innovation process and accelerate the adoption of 3D printing as a mainstream production method for industrial parts.

The platform will create an online ecosystem made up of highly qualified members from areas such as product designers, job shops, part buyers, 3D printer OEMs, material suppliers, expert services providers, micro-factories and much more. Members will be able to instantly connect with other members to initiate co-innovation of products using the latest software tools for additive manufacturing.

For example, a global network of experts all having access to the same gateway could participate in and contribute to the design and development of a re-imagined product for additive manufacturing. Also, part buyers could use the platform to

quickly find qualified services, enhance job scheduling and reduce the time to obtain production quantities of end-use parts at needed locations. At the same time, manufacturing service providers could create a pipeline of job orders for next-generation designs, maximise machine utilisation and expand their businesses. Finally, 3D printer OEMs could connect with the community regarding their latest systems, technology and expertise for repeatable production of industrial parts and quantities.

By exchanging information and practical knowledge, members will have the opportunity to enhance productivity, increase expertise, streamline co-innovation and accelerate the adoption of additive manufacturing technology to a new level of industrial use.

Turning away from trouble

Edgecam benefits from a number of new features. Supplier: Vero

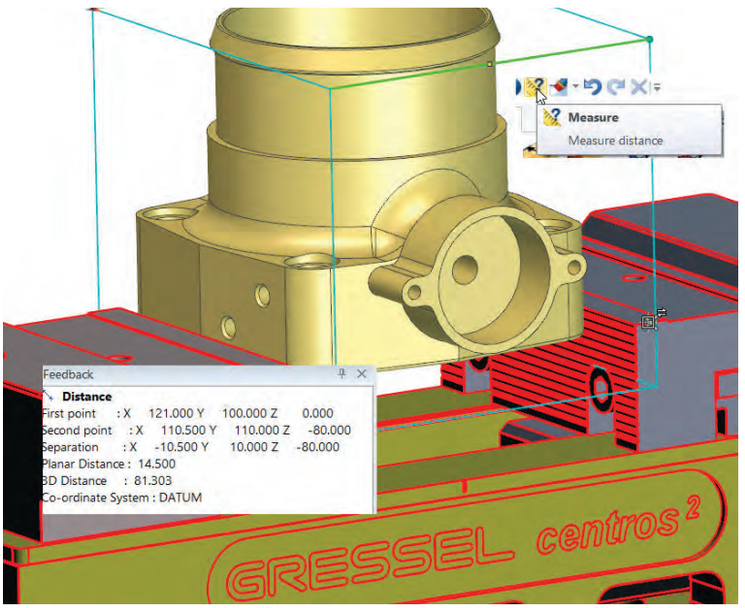
The latest release of Vero's Edgecam software introduces a number of new features and updates, including a new turning cycle that includes B-axis movements while machining on a turning centre. This new feature allows greater accessibility when machining complex profiles, by dynamically positioning the insert.

Edgecam brand manager John Buehler said the toolholder is gouge-protected during deployment, and the user can have additional control over the toolpath by deploying over-ride angles. "This new cycle can be used with all types of turning tools, and for both roughing and finishing operations."

Among other updates, when using the fixture database it is now possible to measure fixtures and other workholding devices. "It's essential to be able to accurately measure the exact position and size of the fixture, as well as clarifying its relationship to components, stock and any other workholders," explained Buehler.

The new release also continues Edgecam's evolution of updating cycle dialogues with pictures and context-sensitive help. "In this instance slot milling, project flow curves and project circular pattern cycles have all been updated," said Buehler. "This feature not only assists regular users to easily interpret infrequently used commands, but it also aids less-familiar users to quickly understand fundamental functionality."

The inspection module offers what Buehler describes as "unparalleled ease of use and sophisticated probe path generation" for both in-process and end-item part inspection. "It provides a robust environment for on-machine probing, supporting a wide array of feature types, path creation and report generation." Responding to the growing need for offline inspection and probing, Edgecam caters for CAM programmers, and utilises CAD models. Using a set of easy-to-use commands, the user creates a set of inspection features that are then converted into a toolpath and simulated. This means the machine code macros are created via Edgecam's postprocessor.



Throwing some complex shapes

CAM is key to machine-time reduction. Supplier: Autodesk

Faced with increasing demand for its products, Hampshire engineering firm Formaplex, which manufactures injection moulds, tooling and thermoplastic and composite components for a range of industries – turned to Autodesk for a software product to underpin its 24-7 manufacturing operation.

Founded in 2001, Formaplex started out as a machining company for Formula One but has since grown to become a tier-one supplier to a host of global, blue-chip customers. And as it has grown – and built on its reputation to meet demanding lead times – production planning has become increasingly critical.

"Some of our customers see us as an emergency service," said machining support manager Rob Carter. "The demands are extremely high to deliver on both speed and quality, and we required more advanced and agile processes to support this. We have to 'play Tetris' in terms of organising jobs across different machines with the capacity hours available to us. We operate around the clock, 24/7 to ensure we meet tight delivery schedules." According to Carter, an investment in Autodesk's PowerMill CAM software has been key to reducing machining times and enabling its engineers use the firm's 5-axis machines to create complex shapes that were beyond the capabilities of its previous CAM product.

What's more, by enabling the rapid calculation of high-quality toolpaths, PowerMill helps make the most of the firm's machining capabilities by ensuring machines are kept running day and night. Increasing automation in this way has improved operational efficiency by speeding up processes and freeing up capacity. PowerMill's automatic collision detection and avoidance functionality also means operators can work safely and in confidence, even when machines are running overnight with offsite monitoring. Programs can be checked prior to cutting and the parts are cut at a faster rate with improved utilisation during the production process.

"By investing in PowerMill we've noticed greater efficiency from our CNC machines," said Carter.

Alongside PowerMill, the firm has also incorporated Autodesk's PowerShape into the design process, with the team using it to review the component and tool to ensure compatibility with their tooling capability for ease of manufacture. "Having PowerShape and PowerMill all under one roof provides a seamless CADCAM package," added Carter. "We're able to extend surfaces for the aid of machining and delivering faster results for our customers. If an engineer has to go back to the CAD designer to ask for changes, our production is slowed. PowerShape and PowerMill working together provides the agility and flexibility that we need for maximum efficiency."

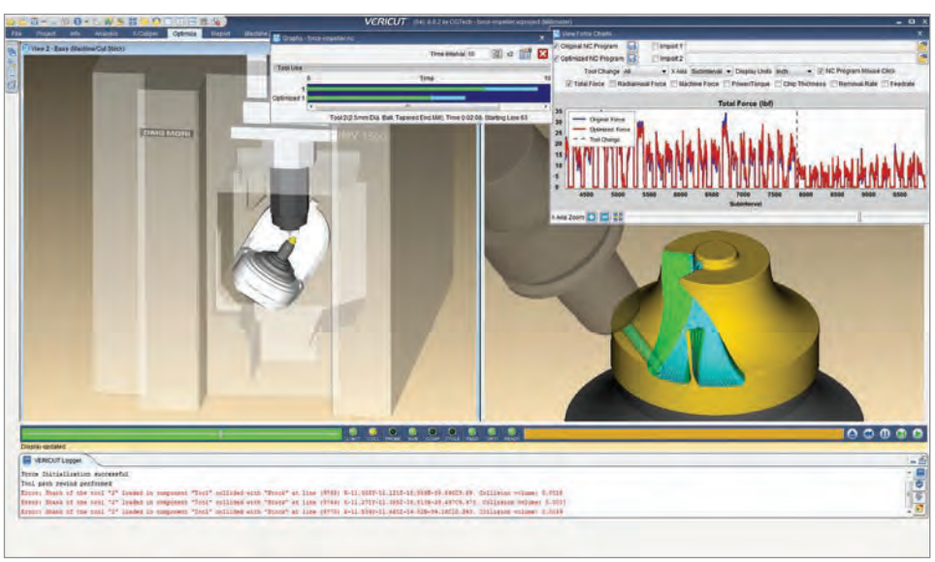
Toolpath optimisation uses physical Force

UK launch of physics-based optimisation method. Supplier: CGTech

CGTech has announced the UK launch of its latest 'physics-based' toolpath optimisation module, Vericut Force.

The Force module is a physics-based optimisation method that determines the maximum reliable feed rate for a given cutting condition based on four factors: force on the cutter, spindle power, maximum chip thickness, and maximum allowable feed rate. It calculates ideal feed rates by analysing tool geometry and parameters, material properties of the stock and cutting tool, detailed cutting-edge geometry, and cut-by-cut contact conditions.

The updated Force module now also receives input values directly from cloud-based tooling, and benefits from many new features that streamline optimisation set-up. By micro analysing the cutting conditions encountered by an NC Program, Force ensures NC programs have optimal feed rates, and ideal chip thicknesses that do not exceed safe force or power limits.



Other new features include improved Charts display, which enables NC programmers and mechanical engineers to virtually 'see' and evaluate force, chip thickness, volume removal rates, and more in NC programs before running on their CNC machine.

Force excels in difficult-to-machine materials, and especially complex multi-axis cuts such as 5-axis flank milling. According to the firm, initial users of the technology are already seeing productivity improvements of up to 50 per cent.

Modern means of metalworking

EMO will provide insights into the technologies and processes that will define the factory of the future

After a gap of four years, EMO – the world's largest trade fair for the metalworking sector – will return to Hanover on 18-23 September.

With more than 2,000 firms from 45 different companies already signed up, EMO 2017 is expected to boast record levels of exhibitors and visitors. In 2013, the fair attracted more than 2,130 exhibitors, and around 143,000 trade visitors from more than 100 different countries.

As well as showcasing the entire gamut of modern metalworking technology – from the latest cutting and forming tools through to computer technology and a host of industrial accessories – this year's event promises a strong focus on some of the trends that are transforming manufacturing: specifically the benefits and challenges of digitalisation and networking.

These issues will be explored in depth in the show's Industry 4.0 area, where a host of academic and industry research groups will showcase industry 4.0 solutions and provide insights into the technologies and processes that will define the factory of the future. One example is the BazMOD project, an initiative involving academics from Stuttgart and Munich, which is considering the development of a standardised interface for the exchange of data within a production environment.

Meanwhile, researchers from Hanover will be revealing the results of their Gentelligent Manufacturing initiative, which has been looking at using new sensing technologies to enhance the performance of machine tools.

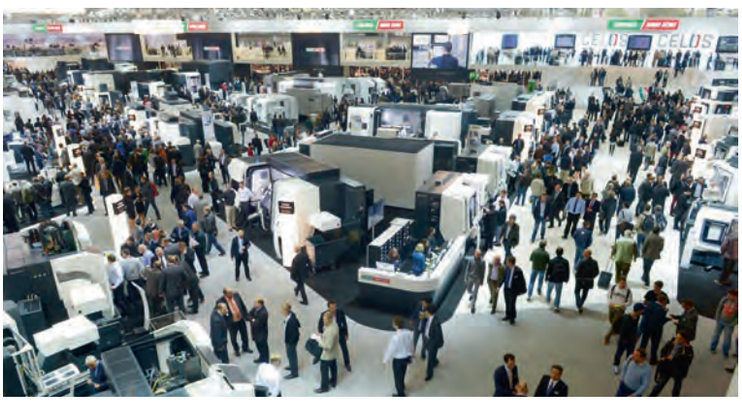
Alongside the academic teams, the Industry 4.0 area will also feature demonstrations from a variety of firms on some of the latest solutions. Exhibits will include a data processing solution based on machine learning, suitable for integration with industrial communication protocols; a robot cell featuring a virtual display of a software package for automation solutions; and a tool dispenser system.

One key exhibitor for whom Industry 4.0 will be taking centre stage is Mazak, which will be unveiling its iSmart factory concept.

Developed to allow machine users to make the step-up from automated cell manufacturing to a connected factory of the future – iSmart is centred on three key pillars: Mazak's so-called Smooth control system; the new SmartBox, which provides faster data analysis with increased security; and the MT Connect standard communication protocol.

Digitalisation will also loom large on DMG Mori's giant stand. As well as around 80 high-tech machine tools, the company will show how it intends to smooth the way to the digital factory of the future for its customers worldwide.

EMO is expected to attract record levels of visitors this year



At the heart of manufacturing

Northern Manufacturing & Electronics returns to Manchester for its fifth consecutive year

Freed from the millstone of its political baggage, 'northern powerhouse' is an epithet that could very aptly be applied to manufacturing and engineering enterprise across the north west region.

Overall, the north west has the second-largest economic output of any region in the UK after the south east. Manufacturing accounts for nearly 16 per cent of the total, the largest contribution of any region in the UK. Key regional industries include pharmaceuticals, transportation and food and drink, together making a massive – and growing – contribution to the UK economy.

The north west's aerospace industry is particularly noteworthy; roughly a quarter of the UK's £32bn aerospace business is based in the north west, employing some 25,000 skilled workers and supporting a rich eco-system of suppliers throughout the country. Automotive and transportation manufacture is also a major contributor to the regional economy, with Bentley, Leyland Trucks, Vauxhall and Jaguar Land Rover all having a substantial presence.

The Northern Manufacturing & Electronics Show's location in central Manchester puts it very much at the heart of this manufacturing activity. Manufacturing as a whole employs nearly one in 10 of the population of Greater Manchester, with no less than 14,375 manufacturing business based in the area. Little wonder that the show has very quickly established itself as both a popular showroom for the latest production technologies and the top showcase for the region's considerable engineering expertise.

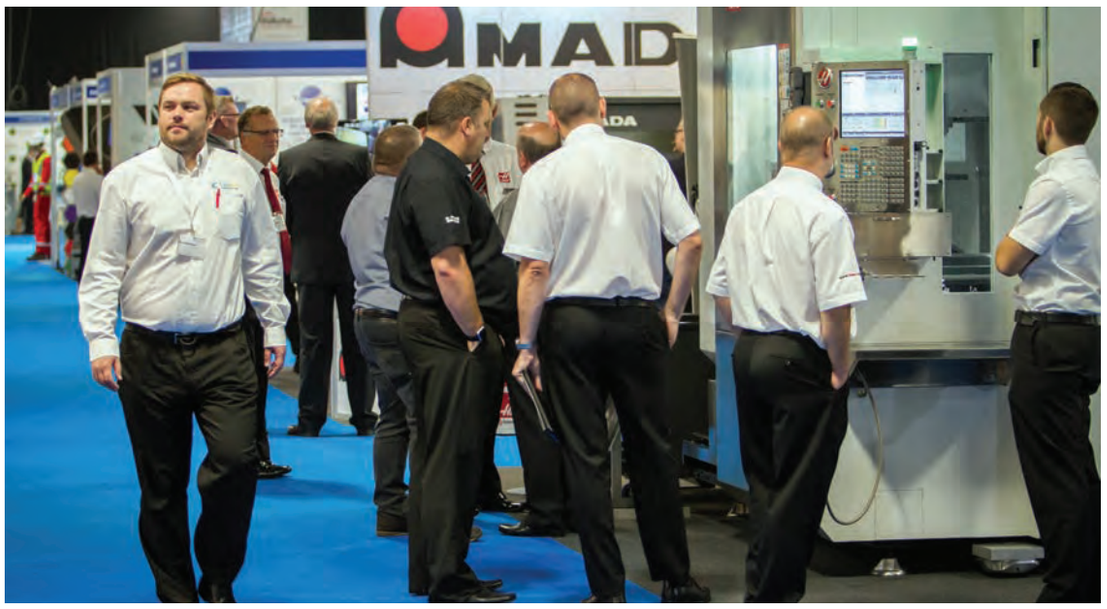
This year's show follows its now familiar format, with the event divided roughly equally between electronics and mechanical engineering, and each sector hosting a mixture of production hardware, components and subcontract services. Incorporated into the event is a specialist RoadRailAir zone, highlighting the region's importance to the supply chain supporting its burgeoning automotive, public transport and aerospace manufacturing sectors. Alongside the show itself is a comprehensive free technical seminar programme, giving visitors the chance of a welcome break from pounding the aisles and the opportunity to learn about the latest ideas in manufacturing from acknowledged experts in their respective fields.

Big names already confirmed for 2017 include Haas Automation, Igus UK, Nikon Metrology, Laser Lines and Olympus Technologies. Yamazaki Mazak will be returning to Northern Manufacturing this year with live demonstrations of its Variaxis range of 5-axis machining centres. Mazak has a long association with UK manufacturing, in particular, providing advanced manufacturing solutions for the aerospace sector, which is very strong in the north of England, making, the firm believes, the Northern Manufacturing & Electronics show the ideal showcase for its machines' capabilities.

Exhibiting for the first time at Northern, YMT Technologies will showcase examples of its advanced CNC machining and turning centres and all aspects of workholding, tooling and accessories. Leading engineering subcontractors exhibiting this year include Jenks & Cattell Engineering, Precision Manufacturing UK and Orbital Fabrications. A wide variety of engineering support services for manufacturing are offered by exhibitors MES (NW), including the commissioning of robotic systems, machine moves and installation.

On the electronics side, Lemo UK returns for 2017 with its comprehensive range of connectors. Niche component exhibitors include magnetic components specialist MagDev. Contract electronics manufacturing services on show include assembly specialists LCL Electronics and multi-discipline service provider Trojan Electronics. Electronics production hardware to be found at Northern 2017 includes soldering, de-soldering and rework stations from PACE Europe, cable preparation and surface mount production from Turner Electronics and modular test and simulation from Pickering Interfaces.

Entry to Northern Manufacturing & Electronics 2017 is completely free to business visitors, and EventCity offers 3,000 free on-site car parking spaces, with easy access by road.



A number of big names have already been confirmed for the show

the ENGINEER collaborate to innovate

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Conference

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Transformative flight path

With impressive growth figures and world-leading innovation, the UK aerospace sector has a lot to offer engineers. Evelyn Adams reports

01/02 Both Boeing and Airbus are recruiting heavily in the UK

At a time when many UK industries are still finding their place on the international stage, the £31bn aerospace sector is a genuine British success story. In the last seven years, productivity in the industry has grown by 19 per cent, compared with just three per cent in the rest of the economy. Now, aerospace companies are looking to recruit talented engineers to sustain that growth.

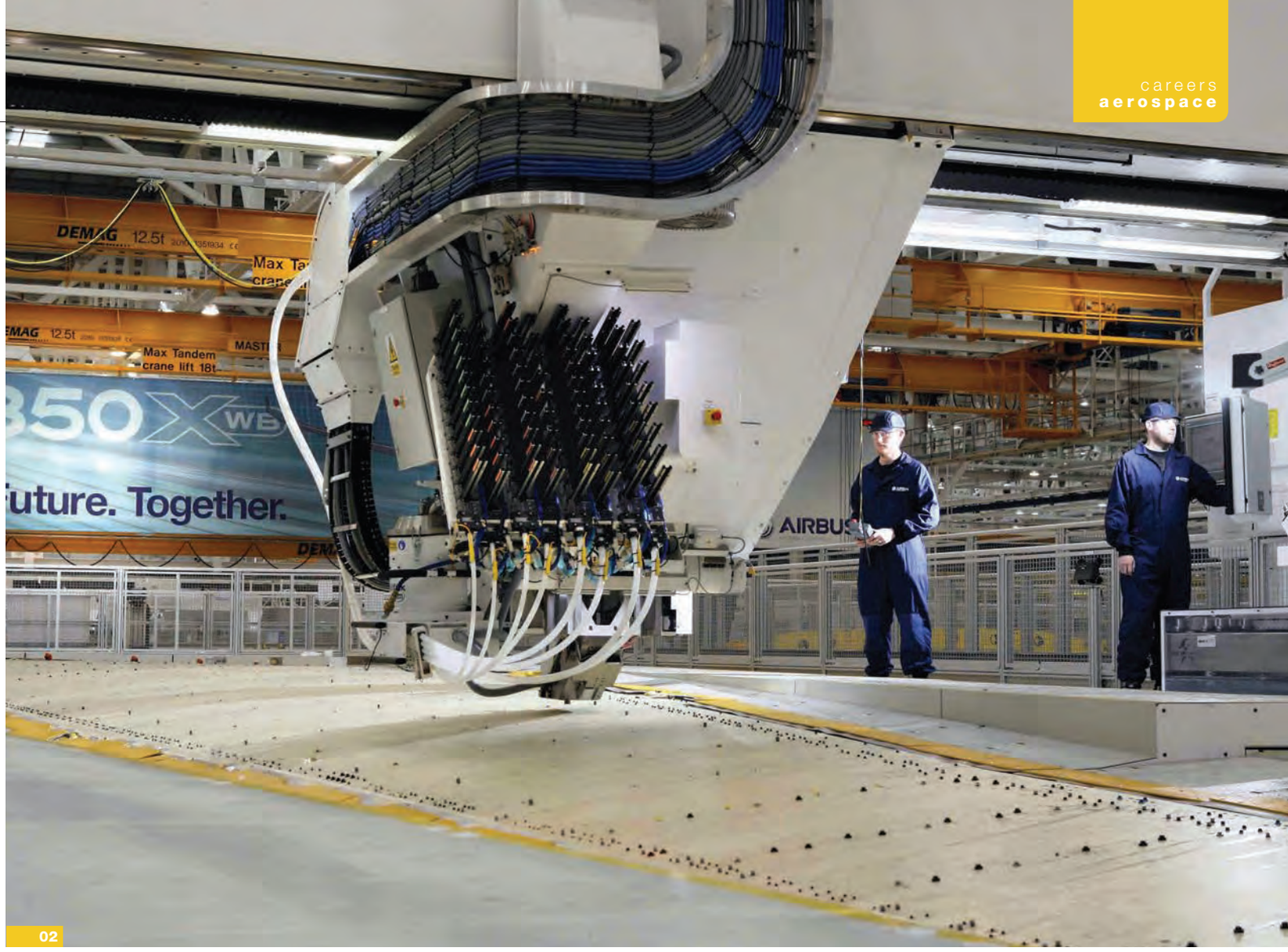
The latest figures from ADS Group, the trade organisation that represents aerospace companies, paint an encouraging picture of the future for any engineers hoping to start a career in the sector. Today, the UK aerospace industry is the second biggest in the world. The industry is growing, with UK aerospace output increasing by 39 per cent since 2011 and annual turnover reaching nearly £32bn. It achieved exports of nearly £28bn in 2016 and is looking to build on success in overseas markets to help drive further sales.

A large part of that success is down to international demand for products in Europe and North America. Around 90 per cent of final demand in aerospace comes from exports, and strong order books means nearly two thirds of UK aerospace companies are expecting growth greater than 10 per cent in the coming years. The current global civil aerospace backlog is worth up to £220bn and there is currently nine years work in hand for the UK.

Opportunities for talented engineers are vast as the industry looks to build on recent strong figures.

With an ageing workforce and a growing skills gap, the industry is ramping up its recruitment efforts. A spokesperson for Airbus, one of the largest recruiters in the sector, said that the company is currently focusing on hiring network and IT systems engineers, software engineers, digital developers, electronics engineers and data scientists. Rival Boeing is also increasing its recruitment efforts in the sector. It is planning to double

01



02

its workforce again in the coming years, having grown from 1,000 people in 2011.

Boeing currently employs 2,000 people in the UK, hiring, on average, a new employee every day. Its spending with the UK supply chain is estimated to be around £1.8bn with 12,700 additional jobs supported in the process. Conrad Ball, who leads Boeing enterprise engineering workforce training and development efforts, said technical skills in areas such as aerospace engineering, electrical engineering, structural engineering are all in demand.

"It is increasingly important that all are well prepared as systems thinkers," said Ball. "There's an emphasis on continuity from innovation to design to development, production, and support as a single conceptual thread. Each engineer needs a really clear understanding of how the decisions that they make contribute to the complete life cycle value of products and services. Along those lines, familiarity with model-based systems engineering is becoming more and more important for engineers in all skill areas."

Alongside this, Ball said there are exciting opportunities in the areas of artificial intelligence, autonomy and analytics. "And many may not realise how important areas such as software engineering and computer programming are for aerospace," he added. "The performance and safety of our complex products and production systems rely on world-class coders, analysts, and modellers."

The UK aerospace industry sector directly employs 120,000 people in the UK and supports a further 118,000 jobs indirectly. The industry, however, faces huge technical challenges that require skilled workers to solve, such as a move towards lowering CO_2 emissions and noise, and incorporating technologies such as augmented reality systems.

Engineers from parallel industries such as automotive can also transfer their expertise across. "We share our focus on technical excellence with a lot of industries," said Ball. "What differentiates Boeing is the complexity of the systems combined with the profound impact that our commercial, defence, space products and services have on billions of people around the world. We seek people to join our team who are ready to take on that responsibility and challenge."

"The pace of change in the industry is so fast especially in terms of industrialising and revolutionising production, that we are increasingly asked to recruit from other industries, primarily automotive," said Ben Birch, department manager of aerospace at engineering recruitment firm, Matchtech. "Automotive is an industry that has already gone through that transition, and its engineers have been using the relevant toolsets for years. As the sector gets serious about automation, engineers from the fast-moving consumer goods, oil and gas, and automotive sectors will be on the wishlist of aerospace employers who need people to help take them on that 'lessons-learned' journey."

Despite UK aerospace boasting strong growth, there are some big challenges ahead and aerospace recruiters know they can't afford to be complacent. Both big companies and the supply chain must meet demand for more advanced and efficient aircraft at competitive prices. They also have to address the growing competition from overseas rivals. Alongside this, uncertainties associated with the UK's exit from the European Union have increased pressure for strong order books.

Birch said potential recruits must understand the aerospace business they will be joining will be going through change. This is exciting, as it offers opportunities for engineers to grow and learn, to shoulder responsibilities, to innovate and to ultimately see their hard work impact on the success of the business. But it is also not without its challenges. "They will have to work at pace, spin many plates and deal with pressure from OEMs to deliver," said Birch.

"If engineers are up for the challenge, the aerospace industry will reward them with significant opportunities to innovate and transform the future of aerospace."

> "It is increasingly important that all are well prepared as systems thinkers"
>
> Conrad Ball, Boeing

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Rapid insert moulding and overmoulding services expanded

Proto Labs has expanded its services.
Sponsor: Proto Labs

Leading digital manufacturer, Proto Labs, has officially launched insert moulding and overmoulding, supported by a fully automated quoting and manufacturing process, across its global business.

Rapid overmoulding and insert moulding processes produce custom prototypes and on-demand production parts in 15 days or less. They use aluminium moulds that offer cost-efficient tooling, and moulded parts that can be manufactured from a range of thermoplastic and liquid silicone rubber materials.

With overmoulding, the production of the substrate parts is a standard injection moulding process involving an aluminium mould with no heating or cooling lines running through it. Cycle times are a bit longer, which allows Proto Labs moulders to monitor fill pressure, cosmetic concerns, and the basic quality of the parts.

When the total run of substrate parts are moulded, overmould tooling is then assembled to the press. The substrate parts are placed by hand into mould where each part is overmoulded with either a thermoplastic or liquid silicone rubber material.

Insert moulding is a similar process but instead uses a preformed part – often metal – that is loaded into a mould where it is then overmoulded with plastic to create a final component. When the run is complete, parts (or the initial sample run) are boxed and shipped shortly thereafter.

Process control tools with multi-window technology

GESIPA® TAURUS® WinTech and FireFox® C WinTech. Sponsor: GESIPA®

For more than 20 years GESIPA® has been able to monitor setting processes that are carried out on safety critical components in many industrial production processes especially automotive sector. The production and installation of airbags, belt restraint systems and child seats have been monitored successfully and efficiently for years. Over the years, GESIPA® has developed technology to such an extent that it is now able to guarantee that the right blind rivet, rivet nut and nut studs are placed in the right place and in the right quantity for vital applications.

The basis for monitoring the WinTech setting process is the tried and tested TAURUS® C. The setting process is evaluated with the aid of position and force sensors as well as integrated electronic circuitry. Up to three evaluation windows can be configured with special setup software. A coloured LED on the tool shows the result of setting process monitoring. With a data line, the values can also be recorded and further processed.

If an irregularity is detected, the process is immediately stopped. It is only after the customer has acknowledged the malfunction that the process can continue – making human error more or less impossible.

July 1945 German revolution

The Engineer didn't hold back on its praise for a German U-boat at the end of the Second World War

After almost a decade in which, presumably for reasons of national security, *The Engineer* studiously avoided discussing the technological advances made during the Second World War, the publication was finally free to look back at some of the engineering strides taken during the conflict

And it's notable that one of the first developments to catch its eye was not one of the many technical advances that swung hostilities in the Allies favour, but a marvel of German engineering: the U-boat.

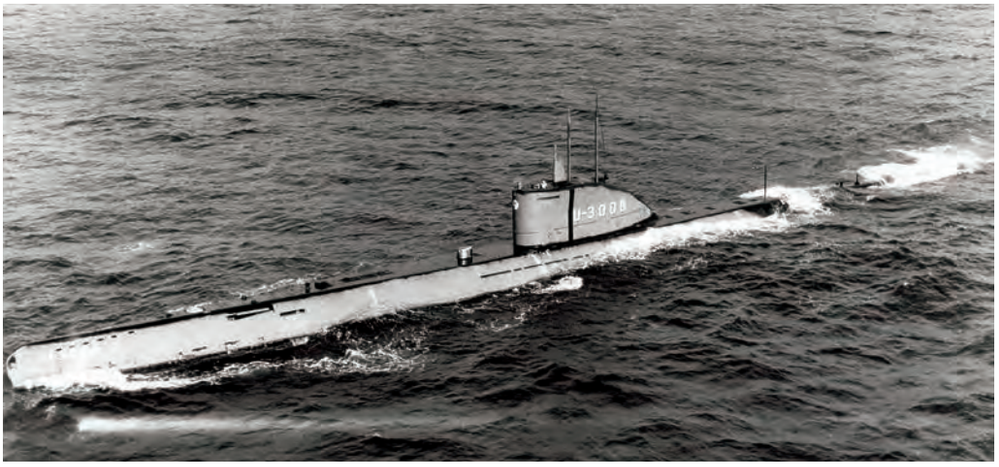
After stepping aboard a captured U-3008 – one of the most advanced versions of the Type 21 U-boat – *The Engineer* didn't hold back in its praise of a boat that it described as "revolutionary in many points of design and performance", and bristling with features that "would make the mouths of British submarine officers water".

Indeed, so advanced did *The Engineer* consider the vessel that it was moved to reference science fiction. "Some of the capabilities of the U-boats of this type are almost reminiscent of the fancies of Jules Verne: nine months below the surface, capable of 16 knots under water in emergency and safe at a depth of 900ft."

The article goes on to discuss some of the key technical innovations of the vessel, and begins by commenting on its "phenomenal" speed.

Interestingly, the boat's surface speed was slow by comparison with British and US subs. But, remarked *The Engineer*, "this submarine was not designed to come to the surface except when entering or leaving harbour" and its submerged speed was a ground-breaking 16 knots, around twice the top speed of existing submarines. The article puts this down to the number of batteries on board and the grouping of the cells.

The article also comments on the boat's ability to rapidly accelerate and decelerate without altering its depth. Typically, with existing submarines, a sudden increase in speed would cause the bows to rise, largely due to increased pressure above the line of thrust of the propellers caused by the conning tower and the bridge. This didn't seem to be a problem for the Type 21 as the engineers had cleverly found a way to automatically adjust the hydroplanes when acceleration began to take effect.



The U-3008 was one of the most advanced Type 21 U-boats to be produced by Germany in the Second World War

The vessel was also immensely strong, reported the article, thanks largely to an innovative figure-of-eight hull design. "The section amidships consists of the usual circular section pressure hull, with beneath it another smaller circular section pressure hull," wrote *The Engineer*. "These two circular section hulls are not separate, and, in effect, they form part of the same 'figure-of-eight' sectioned pressure hull. Each part is not only immensely strong in itself; they are joined by very strong plating which is worked on a curve so that there is no weakness at the junction of the two parts of the hull."

Finally, the article spares a thought for the mariners who lived and worked on the vessel, and remarks that they actually enjoyed relatively spacious and comfortable quarters. "If a submarine is designed to remain at sea and submerged for very long periods, one of the primary considerations must be habitability and in the U-3008 there is a comfortable sprung bunk for every member of the crew, and every bunk is provided with a fitted mattress."

The Engineer was impressed, but also keen to stress the achievements of Germany's submarine builders shouldn't reflect badly on British engineers.

"Nobody can visit the German ports without realising that a very high proportion of the whole war potential of the country was devoted to the production of U-boats, and that designers and constructors had been given a far greater degree of freedom than has ever been accorded to them on this side of the North Sea."

By contrast, the magazine wrote, British scientific and engineering efforts were spread across a wider range of activity: "The contrast between Germany and Great Britain is one of highly specialised effort on the one hand, as against a potential which has had to be used sparingly in certain fields in order that there should be enough of everything." **JE**

Word of the issue

Anthony Poulton-Smith explores the origins of the word ‘engine’

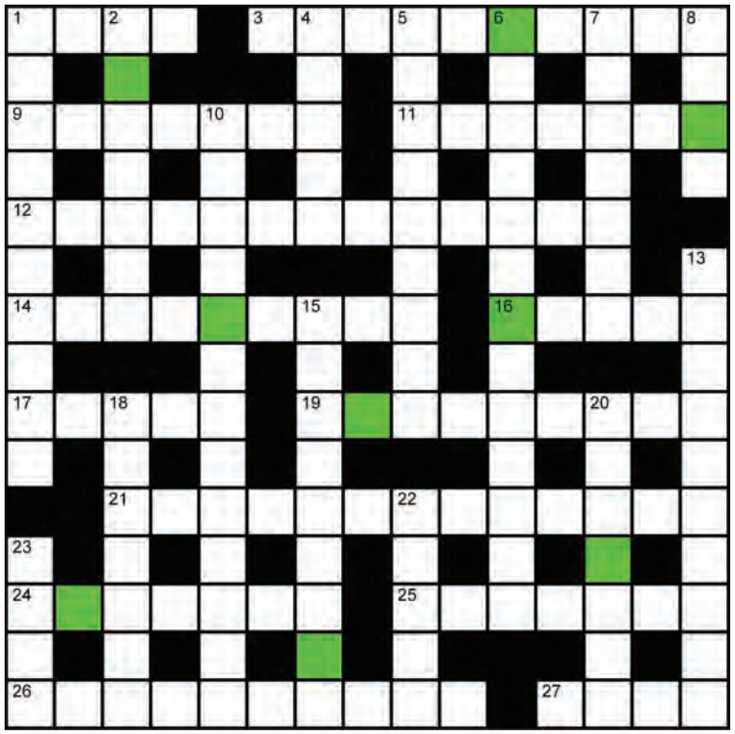
Engineering would never exist without the engine, not only from a technological viewpoint but also the etymological perspective. The ‘engine’ has not always referred to power derived from a chemical reaction.

Despite it being the ancient equivalent of winding a rubber band, the trebuchet or catapult is, by definition, a mechanical device using power to do work and therefore qualifies as an ‘engine’. Its early use in English leaned more towards ‘manner of construction’ as in the modern ‘engineered’, but also used to mean ‘skill, craft’ and also ‘trickery, deceitfulness’. It came to English from Old French engine ‘skill, wit, cleverness’, and from Latin ingenium ‘innate qualities, ability’.

Those last two are the true origin, for this comes from Proto-Indo-European en gen-yo where en or ‘in’ precedes the root of gene meaning ‘give birth, beget’.

Bigpicture

HMS *Queen Elizabeth* successfully passes under the Forth Rail Bridge prior to commencing first-stage sea trials off the north-east coast of Scotland. The future flagship will now spend around six weeks at sea for trials that will monitor the carrier’s speed, manoeuvrability, power and propulsion.



Prizecrossword

When completed rearrange the highlighted squares to spell out someone new to the offshore oil industry. The first correct answer received will win a £20 Amazon voucher. Email your answer to **jon.excell@centaur.co.uk**

Across

1 Pictures illustrating textual material (4)
3 Relating to a flowing charge (10)
9 Turned in a circle around an axis (7)
11 Part of the whole (7)
12 Worked very hard (5,4,4)
14 Expert in TV and newspapers (5,4)
16 Senior member of a profession (5)
17 Remove from memory or existence (5)
19 Scientist dealing with matter and energy (9)
21 Beyond what is usual (13)
24 Non-steroidal anti-inflammatory drug (7)
25 Light raft made of balsa (3,4)
26 Removed water with spinning (7,3)
27 Goggle box (4)

Down

1 Attack with incendiary devices (10)
2 Obtain something for a specific purpose (3,4)
4 Carrying cargo (5)
5 A careful look at some social unit (4,5)
6 Wheel gear meshed with a toothed frame (4-3-6)
7 Uneven by virtue of having ripples (7)
8 One loop of chain (4)
10 Involved in the act of caring (13)
13 Cheap lumber used especially for panelling and furniture (6,4)
15 Without apparent forethought (9)
18 A list of matters to be taken up (7)
20 To think/believe (7)
22 Machine for smoothing grain or hay (5)
23 Separate with a straining device (4)

June’s highlighted solution was Throughput. Winner: **Alan Mulley**

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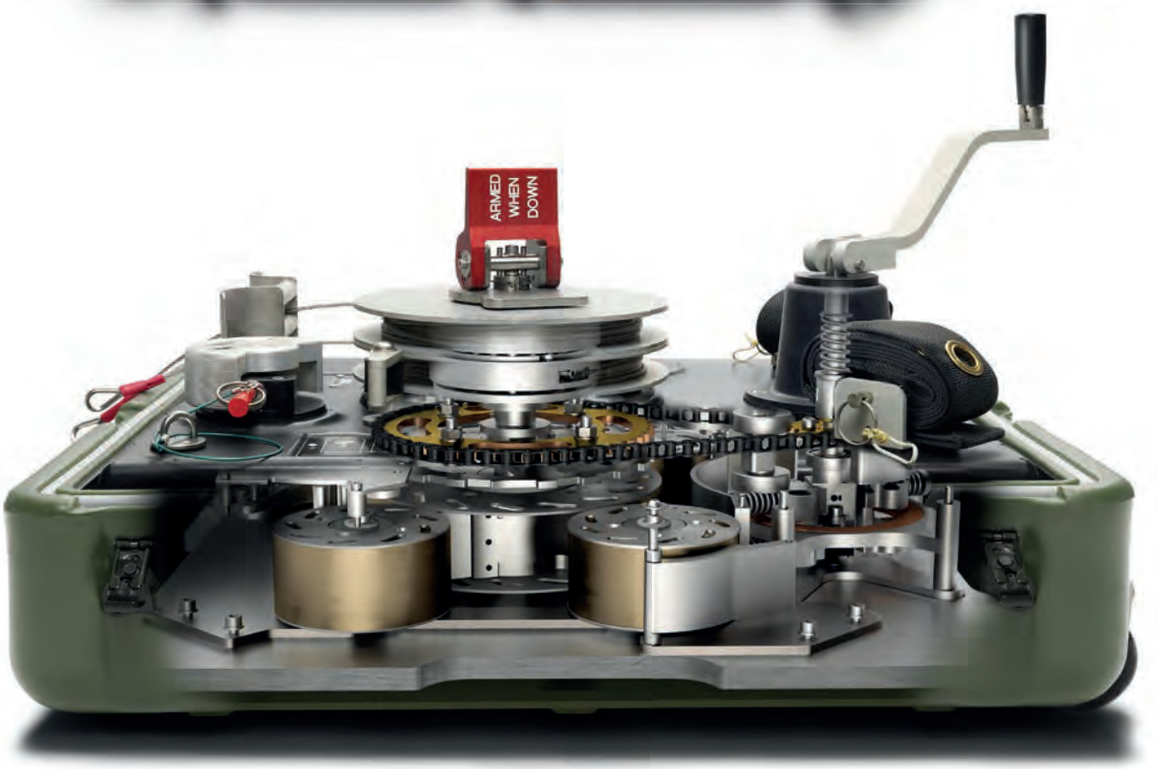

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