

THE ENGINEER

MARCH 2020

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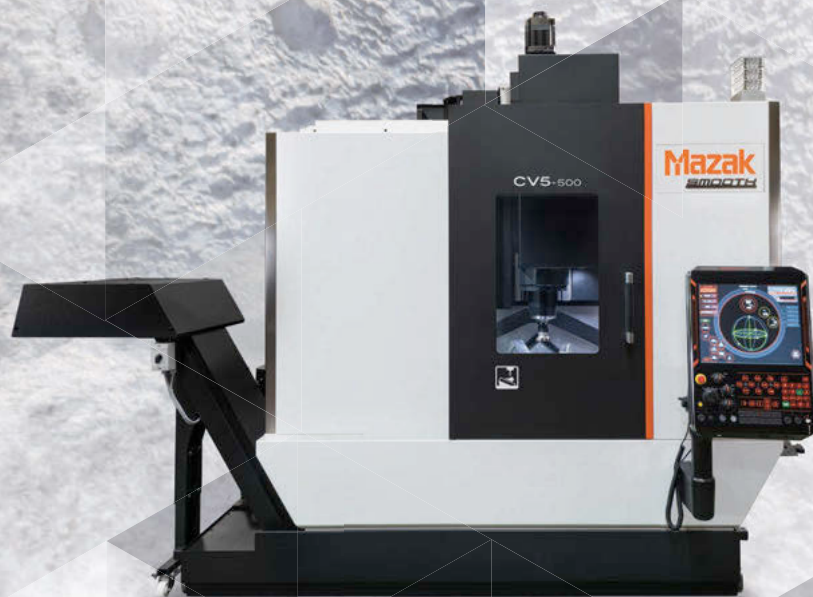
LATE GREAT ENGINEERS: RAILWAY PIONEER AND ORIGINAL ROCKET MAN ROBERT STEPHENSON

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COVER IMAGE: Magway

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SCAN ME



JON EXCELL

Solving the “last mile” logistics conundrum

Most of us take it for granted. But we now live in an age of retail marvels, where pretty much anything – from that obscure vinyl LP to a family pack of beans – can be ordered and enjoyed without having to leave the house.

The ability to have what we want delivered to our homes, often within 24 hours, has become so much a part of daily life that whilst many of us may bemoan the death of the high street, there are few who aren't least a little complicit in its demise.

In recent years we've reported on many of the innovations and applications of engineering technology that have led to this: such as the advanced robotics systems at the heart of the giant warehouses operated by the likes of Amazon and Ocado. Indeed, such organisations have become trailblazers for the kind of smart automation technologies that are now being deployed by other sectors such as automotive and aerospace.

But the convenient consumerism delivered by these technologies comes at a cost, in the form of the ever-increasing number of delivery vehicles required to support our growing appetite for online shopping.

Addressing the so called “last mile” challenge has now become a major priority for planners, logistics firms, transportation specialists and retailers, and in this issue's cover story (*Crate Expectations*, page 18) we take a look at some of the fascinating concepts that could help take freight off the roads and deliver a truly smart end-to-end retail experience, where the application of technology doesn't end when the customer's order leaves the warehouse.

Elsewhere in this issue, we turn to other disruptive trends, ranging from the ways in which biometric technologies might make the password a thing of the past (page 48), to our Q&A feature (*Helping Hands*, page 50) examining the ways in which “cobot” technology is helping to bring the benefits of automation to all.

As always, there's also a nod to the past - from our archive feature, which takes a timely look at The Engineer's early coverage of the Thames Flood barrier, to the latest installment in our Late Great Engineers series (page 54) which this month looks at the career of railway pioneer Robert Stephenson, an engineer who would surely be fascinated by the kind of transportation and logistics challenges described in this issue.

Jon Excell

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Industry's digital transformation; Huawei or not Huawei; and the challenges of net-zero

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MISSION STATEMENT

The aim of The Engineer is to champion and promote engineering innovation and technology development across all of the UK's key engineering sectors.

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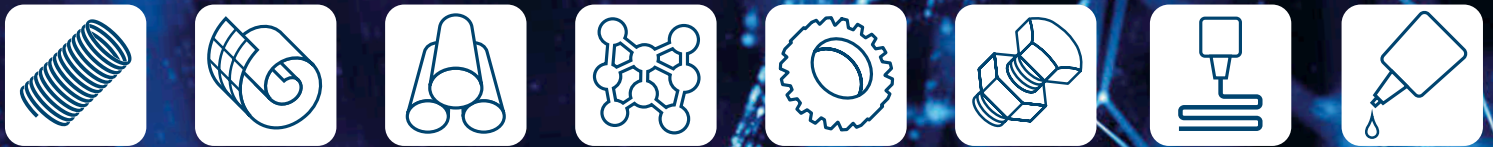
THINGS WE'VE LEARNT THIS ISSUE

- 1 Coal to be phased out of UK energy mix by October 2024
- 2 Metropolitan police using live facial recognition technology
- 3 Battery electric vehicle registrations rise by more than 200 percent YOY
- 4 60 per cent of readers believe aviation's growth and low carbon ambitions are incompatible
- 5 George Stephenson (Robert Stephenson's father) was illiterate until the age of 18

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- Insulin-delivery patch monitors and manages glucose levels

MANUFACTURING

- Laser process etches anti-fouling hull surface

Nissan Leaf completes 230-mile autonomous UK road journey

Complex real-world trial aims to make driverless cars more “human-like”

JON EXCELL REPORTS

A research vehicle developed by Nissan has completed a 230-mile self-navigated trip from the firm's European Technical Centre in Cranfield to its Sunderland manufacturing plant.

The journey marked the culmination of the HumanDrive project, a three-year long Nissan led initiative primarily aimed at developing technology that can help autonomous cars drive in a more “human-like” manner, thereby helping passengers to feel more comfortable with the technology.

The £13.5m project, which included a consortium of nine industry partners and was funded by the Centre for Connected and Autonomous Vehicles (CCAV) consisted of the 230-mile “grand drive” from Cranfield to Sunderland, and a test track-based activity that looked at how AI could be used to further improve the performance of autonomous vehicles.

Nissan's Bob Bateman, project leader, explained that the grand drive enabled the group to put its technology to the test in one of the world's most complex and unique road environments.

“The HumanDrive project allowed us to develop an autonomous vehicle that can tackle challenges encountered on UK roads that are unique to this part of the world, such as complex roundabouts and high-



speed country lanes with no road markings, white lines or kerbs,” he said.

Enabling autonomous vehicles to deal with these conditions in a recognisably human-like way will be key to driving consumer confidence in the technology, he added.

“This project aimed to use advanced technologies for autonomous vehicles to try and emulate a human-like experience to ensure that the customer feels comfortable and safe. We're trying to move from a taxi service to a luxury chauffeur surface.”

The trials used a heavily modified Nissan Leaf, with racks of computers in the boot and a range of radar, LIDAR and camera systems, plus a highly accurate differential GPS system, that is used to build up a perception of the world around it.

Commenting on the use of the Leaf for the project, Nissan research engineer Chris Holmes said: “It's our key icon for intelligent mobility research.

“Also, electric vehicles lend themselves quite well towards utilising computers in the boot and also have nice clean electric power source for running the system.”

An additional element of the project, carried out on Nissan's private test track, used technology developed by consortium partner Hitachi Europe Ltd to explore how real-time machine-learning AI could be used to further enhance the performance of driverless cars.

Nick Blake, chief innovation strategist at Hitachi explained that this system uses a dataset of previously encountered traffic scenarios and solutions, so-called “learned experience”, to enable the vehicle to recognise and cope with future scenarios that it may encounter.

He added that through the project the group developed an easily reconfigurable AI technology that enables autonomous vehicles to have different driving styles for different people.

Read more at www.theengineer.co.uk

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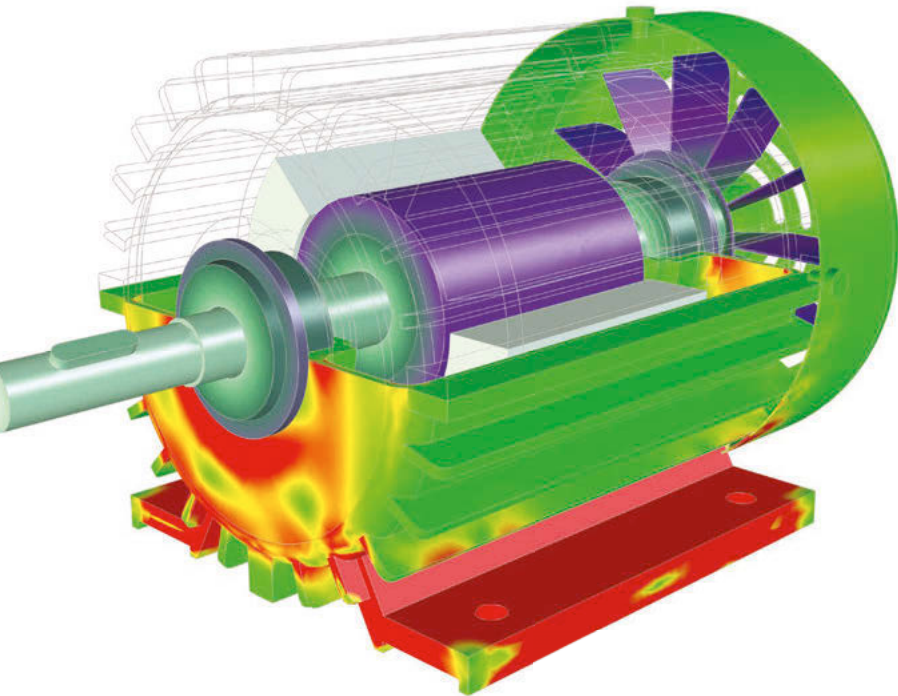
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Thales to deliver CMS to T31 frigates

JASON FORD REPORTS

The Royal Navy's new fleet of T31 general purpose frigates will be equipped with TACTICOS, a highly-automated combat management system developed by Thales.

The company began working on the CMS in the early 1990s, describing it as 'an integrated and highly automated multi-warfare CMS to manage command and weapon control functions' on surface ships. Currently being developed for the Royal Navy's requirements at Thales' new naval combat management centre in Crawley, the CMS for the T31 will be fully integrated with the vessel's lead NS100 radar and other sensors and weapons to help navy warfare teams rapidly assess whether nearby air and sea platforms present a threat.

Already in service with 24 navies globally and on 182 different ships, TACTICOS is fully configurable for rules-based engagement with current and emerging threats.

Speaking at the firm's site in Crawley, Mark Harvey, Team 31 Deputy Programme Director said: "The introduction of TACTICOS and new mission system capabilities to the RN delivers a truly open-architecture CMS and a sovereign capability that the UK MoD will utilize on the globally deployed T31 general purpose frigates. Not only

will the RN benefit from joining the TACTICOS user community with 24 other navies around the world they'll be able to develop their TACTICOS system further, ensuring the sovereign capability of their CMS remains within the UK."

Five T31 frigates will be delivered to the Royal Navy at a cost of around £250m per ship. Thales, as part of Babcock Team 31, will be the mission systems integrator for the Type 31 programme, delivering the combat system, communications systems and the navigation and bridge system. The first ship is scheduled in the water in 2023.

Harvey said: "Team 31 is rapidly mobilising and investing in our Babcock Rosyth facility with...groundbreaking about to commence for a new...build hall capable of housing two T31 frigates, enabling a parallel build, delivering efficiencies...and delivering on the national ship building strategy in a ship building facility that the UK can be proud of."

The contract to deliver the T31s is expected to secure some 1250 direct jobs at locations around the UK at the height of the project, as well as a similar number in the supply chain. Babcock expects to develop around 150 new technical apprenticeships for the project.



NEWS IN BRIEF

SPACE INVESTMENT

Shetland Space Centre's (SSC) plans to build and operate the UK's only satellite launch site have moved forward with a £2m investment. Leonne International will take a 20 per cent stake in SSC, which will use the financing to develop the launch site and ground station on the island of Unst in Shetland. Unst was identified in a report commissioned for the UK Space Agency as the optimal location in the UK for launching small satellites.

TALENT UNTETHERED

A fast-track visa scheme is expected to come online that will allow an uncapped number of suitably qualified people into the UK. From February 20, 2020 people entering the UK under the government's Global Talent Visa scheme will require endorsement from UK Research and Innovation (UKRI) but will not be required to hold an offer of employment before arriving and will not be bound to a specific job.



FOSSIL FUEL PHASE OUT

Coal will be phased out of Britain's energy mix by October 1, 2024, a year ahead of schedule and in line with government's net zero ambitions. Britain's greenhouse gas emissions fell 2.1 per cent between 2017 and 2018, which has been partly attributed to the decline of coal-powered electricity generation. In 2019, over half of Britain's electricity came from low-carbon sources. In total, the UK's GHG emissions have fallen 43 per cent since 1990.

Read more at www.theengineer.co.uk



Small Robot Company reveals production partner

ANDREW WADE REPORTS

UK agritech startup Small Robot Company is working with Northumberland's Tharsus to build the first batch of its weed mapping robot, Tom.

The autonomous farmbot features a double camera system that captures precise plant data and enables farmers to monitor crops on an individual level. According to SRC, Tom can cover around 20 hectares per day, feeding about six terabytes of data back to an artificial intelligence system dubbed Wilma, which helps

farmers interpret the information. Alongside Tom, SRC has plans for robots called Dick and Harry, which will focus on weed control and planting, respectively.

Tharsus will work with SRC to refine Tom's design before producing an initial run of 10 robots. The first of these should be ready in October 2020, with a planned 2,000 hectares being serviced by the fleet come January 2021. Early customers include Waitrose and the National trust, which are part of SRC's ongoing field trials across 20 UK farms.

"The global opportunity is immense," said Sam Watson-Jones, Small Robot's co-founder. "We have ambitious plans to tackle the international market: this partnership with Tharsus is critical to reliable delivery at scale. Our intention is that this would be a strategic and longer-term partnership to support all of the robot manufacture for our initial commercial delivery."

By 2023, SRC plans to be managing 20,000 hectares of UK farmland under a farming as a service (FaaS) model, where all three robots work in tandem with Wilma to maximise yield with minimal inputs and waste.

Part of that strategy will see the introduction of non-chemical weeding, with the Dick robot delivering high voltage to weed roots. The weed zapping service is not expected to go live until autumn 2021, but Watson-Jones sees plenty of opportunities for the company in the meantime.

"We're already actively working to monetise other opportunities for our existing technology," he explained. "This means we won't need to wait for non-chemical weeding to be developed before we start growing our revenues. There are routes to market for Tom and Wilma into other parts of the agri industry, including machinery companies, seed companies and chemical companies."

LIFT-OFF FOR SUN ORBITER

A European Space Agency led mission that will shed new light on the sun has successfully launched from Cape Canaveral.

Launched on 10th February aboard an Atlas V 411 rocket, the Solar Orbiter mission will provide the first views of the Sun's uncharted polar regions, which scientists believe are key to understanding the activity of the star. It will also investigate how intense radiation and energetic particles being blasted out from the Sun and carried by the solar wind through the Solar System impact our home planet. This will help scientists better understand and predict periods of stormy 'space weather'.

The satellite at the heart of the project, built by Airbus Defence and Space, will take just under two years to reach its initial operational orbit, making use of gravity-assist flybys of Earth and Venus to enter a highly elliptical orbit around the Sun.

The spacecraft's payload of scientific instruments will be protected by a heatshield covered in a special heat-emitting coating called SolarBlack. **JE**

Read more at www.theengineer.co.uk

HEAVY HAUL FOR HYDROGEN

JASON FORD REPORTS

The world's largest hydrogen powered mine truck is being developed by Anglo American in collaboration with Williams Advanced Engineering.

The ultra-class Fuel Cell Electric Vehicle (FCEV) is part of FutureSmart Mining, a sustainability programme at Anglo American aiming to reduce the company's greenhouse gas emissions by 30 per cent by 2030.

Julian Soles, Anglo American's head of technology development, said

the work with Williams will push the mining company toward its ultimate goal of operating a carbon-neutral mine.

The FCEV truck's hydrogen fuel cell will be paired with WAE's modular lithium-ion battery system, an arrangement controlled by a high voltage power distribution unit delivering over 1,000kWh of energy storage.

The power units will be designed and built at WAE in England and integrated into an existing mining haul truck, with testing taking place later this year

at Platinum Group Metals' Mogalakwena mine in South Africa.

Through regenerative braking, the battery system will be capable of recovering energy as the haul truck travels downhill. Studies will take place to ascertain how the power units can be used to provide so-called second life energy storage solutions.

"Operating within a harsh environment is something we are familiar with as sole battery supplier for the Extreme E [off-road EV] programme and we remain committed to supporting long-term sustainability projects," said Craig Wilson, MD of WAE.





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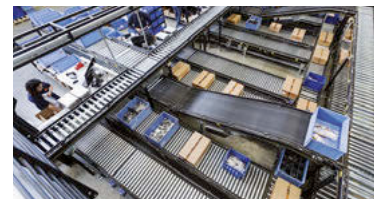
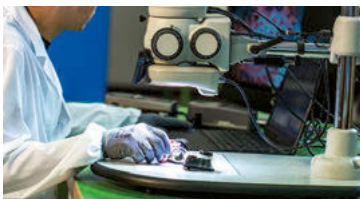
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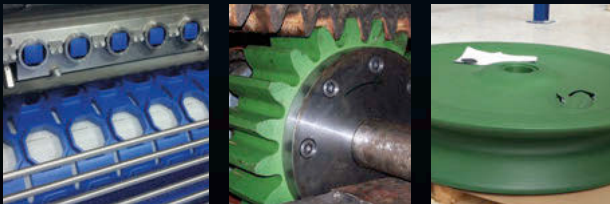
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Prosthetic gives jellyfish super speed

Bionic jellyfish could explore oceans

ANDREW WADE REPORTS

Engineers in the US have used a small pulsing prosthetic device that directs jellyfish to swim at up to three times their normal speed.

Acting like a pacemaker, the prosthetic encourages jellyfish to speed up their natural pulsing motion, which they use to move through the oceans and capture prey. Typically, this motion sees the creatures move at around 2cm per second. With the device attached, that speed increases to between 4cm and 6cm per second.

Measuring around 2cm in diameter, the microelectronic prosthetic is naturally buoyant

and attaches to the animals via a small wooden barb. Once removed, the jellyfish return to their normal swimming speed and the researchers claim that the process does not appear to cause stress to the creatures. It is hoped that the bionic jellyfish could one day be used to help in ocean exploration. The research is published in *Science Advances*.

"We've shown that they're capable of moving much faster than they normally do, without an undue cost on their metabolism," said Stanford University graduate student Nicole Xu, co-author of the study.



In addition to making the jellyfish faster, the electrical jolts also made them swim more efficiently. Although the jellyfish swam three times faster than their usual pace, they used just twice as much energy to do so, as measured by the amount of oxygen consumed while swimming. This combination of speed and efficiency opens up the possibility of using jellyfish to help gather data from the world's oceans.

"Only a small fraction of the ocean has been explored, so we want to take advantage of the

fact that jellyfish are everywhere already to make a leap from ship-based measurements, which are limited in number due to their high cost," said research lead John Dabiri, Professor of Aeronautics and Mechanical Engineering at Caltech.

Currently, the prosthetic can direct jellyfish to start swimming and control its pace. The next step will be to develop a system that guides them in specific directions and allows them to respond to signals from onboard sensors, according to Dabiri.

MET POLICE RECRUIT NEOFACE

Facial recognition system used to collar criminals

JASON FORD REPORTS

NEC's NeoFace Live Facial Recognition technology is being used by London's Metropolitan Police Force in the fight against crime.

The Met has deployed NEC's LFR for what it describes as intelligence-led operations into specific locations to help combat crimes including knife and gun crime, and child sexual exploitation.

In use, NeoFace takes images and compares them to those of people on a watchlist. It works by measuring the structure of each face, including distance between eyes, nose, mouth and jaw to create a facial template. The MET said the NeoFace is not linked to other imaging systems, such as CCTV or body-worn cameras.

"We are using a tried-and-tested technology, and have taken a considered and transparent approach in order to arrive at this point," said Assistant commissioner Nick Ephgrave in a statement. "Similar technology is already widely used across the UK, in the private sector. Ours has been trialled by our technology teams for use in an operational policing environment."

"This is a dangerous, oppressive and completely



unjustified move by the Met. Facial recognition technology gives the State unprecedented power to track and monitor any one of us, destroying our privacy and our free expression," commented Clare Collier, advocacy director of civil rights group Liberty. "Rolling out a mass surveillance tool that has been rejected by democracies and embraced by oppressive regimes is a dangerous and sinister step. It pushes us towards a surveillance state in which our freedom to live our lives free from State interference no longer exists."

GRAPHENE AMPLIFIED

Physicists at Loughborough University have used graphene to create an amplifier that can tune into previously untapped terahertz (THz) frequencies.

THz waves have so far not been exploited due to their low energy, but the new device enables the detection and amplification of the elusive waves and could potentially open up brand new technologies in medicine, cosmology, telecoms and satellites.

It consists of a new type of optical transistor - a working THz amplifier - using graphene and a high-temperature superconductor. When the THz radiation hits the graphene outer layer, the trapped particles inside attach themselves to the outgoing waves giving them more power and energy than they arrived with - amplifying the signal. **AW**



Read more about batteries at www.theengineer.co.uk



SMMT APPEALS FOR FREE TRADE AGREEMENT

The head of SMMT is urging Brexit negotiators to deliver ‘an ambitious free trade agreement with Europe’.

Mike Hawes, chief executive of SMMT, the UK’s automotive trade body, made the appeal on the publication of figures showing a 14.2 per cent drop in car production in 2019.

The drop to 1,303,135 units has been attributed to factors including weakened domestic consumer and business confidence, weaker demand from overseas markets, model production changes, and less appetite for diesel models.

Hawes, said: “Given the uncertainty the sector has experienced, it is essential we re-establish our global competitiveness and that starts with an ambitious free trade agreement with Europe, one that guarantees all automotive products can be bought and sold without tariffs or additional burdens.

“This will boost manufacturing, avoid costly price rises and maintain choice for UK consumers. Negotiations will be challenging but all sides stand to gain and this sector is up for it.” JF

Stadler awarded £700m Metro rail contract

Swiss firm beats competition for long-term Tyne and Wear deal

JASON FORD REPORTS



Stadler has been awarded a contract worth up to £700m over 35-years for the supply and maintenance of an initial 42 trains to Tyne and Wear’s Metro network.

The Department for Transport is providing £337m to Nexus, the Newcastle-based transport authority, towards the cost of the programme which will deliver trains up to 2024. The initial order for trains could increase to 46 if Nexus increases the frequency of Metro services.

“We asked for the best trains for the best price – based on what local people said they wanted to

see, providing excellent reliability for years to come...Stadler has delivered on all fronts,” said Tobyn Hughes, MD of Nexus.

As part of the deal, Stadler will build and operate a £70m maintenance facility at an existing Metro depot site in South Gosforth, Newcastle. Nexus will lead the construction of a satellite depot at Howdon, North Tyneside.

According to Nexus, Stadler will deliver the contract – which includes decommissioning the existing Metro fleet – with over 30 new UK supply chain partners.

Councillor Martin Gannon, leader of Gateshead Council

and Chair of the Joint Transport Committee for North East England, said: “These new trains will be rooted in our region – they are designed based [on] what more than 3,000 passengers told us what they wanted from their daily journey.

“They will be built and brought into service by exploiting manufacturing excellence in new supply chains here in North East England and across the UK. They will be maintained and operated by the proud workers who make Metro happen.”

The decision to award the contract to Bussnang, Switzerland-based Stadler has been described by trade union Unite as ‘especially galling’ with Hitachi Rail’s factory at Newton Aycliffe located in the region.

Pat McCourt, Unite’s regional officer said: “The failure of Hitachi to be awarded this contract is a huge blow to the local community, which has been severely neglected for the last decade.

Read more at www.theengineer.co.uk

Government approves UK Huawei 5G involvement

US misgivings over deal despite assurances from UK intelligence

Despite warnings by the Trump administration, the prime minister Boris Johnson has given the go ahead for Chinese firm Huawei to supply technology for the UK’s 5G mobile network.

The decision to allow the company to play a role in the network has been viewed as something of a snub to the US which has claimed that allowing the Chinese firm a role in 5G risks giving the Chinese government a back door into the UK’s telecoms network.

Matt Pottinger, Donald Trump’s deputy national security, is widely reported as saying it would be ‘nothing short of madness’ to use Huawei’s technology in the UK’s 5G network and has warned that any involvement would impact

intelligence sharing between the two countries.

Taking to social media, Republican senator Mitt Romney said: “The UK is sacrificing national security and inviting the CCP’s surveillance state in.”

UK intelligence services have advised the government that the firm’s involvement in “non-core” elements of the system would not present a security risk and in a statement UK foreign secretary Dominic Raab announced a tightening of these restrictions, confirming that the firm would be excluded from all safety and security critical aspects of the network and that its market share would be capped to 35 per cent.



Many senior Tories, including former cabinet members Iain Duncan Smith, Liam Fox and David Davies, are reportedly alarmed by the decision, amidst concerns that it could undermine efforts to secure a favourable trade deal with the US following the UK’s exit from the EU on January 31, 2020. JE

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The UK's two-year old children will be eligible to drive in 2035, and their motoring experience will be defined by technological, legislative and behavioral changes that are taking place today.

By the time they learn how to drive, battery (BEV) and other alternatively fueled electric vehicles will dominate the nation's roads and for a certain urban demographic, the notion of vehicle ownership will probably lose ground to those seeking mobility as a service (MaaS) solutions.

Petrol and diesel vehicles will not disappear overnight but from 2035 manufacturers will not be able to sell new petrol and diesel cars, vans, or so-called hybrid vehicles.

The government's decision to phase out these vehicles was announced in 2018 with a deadline of 2040 that was brought forward at the launch COP26 on February 4, 2020. Transport secretary Grant Shapps later hinted that the timeline could shift again to 2032.

Mike Hawes, chief executive of automotive trade body SMMT (Society of Motor Manufacturers & Traders) responded by saying that 2035 was a 'date without a plan', citing vehicle expense, relatively low sales, 'a woefully inadequate' charging network, and lack of clarity on the plug-in car grant as factors that will stymie the uptake of BEVs and other relevant alternatively fueled vehicles (AFVs).

According to SMMT's monthly round-up of new car registrations, 148,997 new cars were registered in December 2019, with BEVs making up 4,939 of the total compared to diesel (33,884) and petrol vehicles

Adapt and survive

The phasing out of petrol and diesel vehicles should be seen as an opportunity for manufacturers

WRITTEN BY JASON FORD

(94,251). Compared to same period in 2018, however, BEVs saw their share of registrations rise by 220.7 per cent, and other forms of AFV experienced a rise in registrations over the same period.

For Nigel Morris, electric vehicle integration manager at the Active Building Centre, government should look at Norway to address affordability.

"Price parity has been engineered through EVs being exempt from non-recurring vehicle fees, such as purchase taxes and 25 per cent VAT," he said. "This has resulted in a dramatic proportional increase of EV sales with over 75 per cent of new car sales in 2020 being electric."

According to Morris, the 12-to-15-year timeline will also be

a factor in driving down the cost of new vehicles.

"With every new EV model launched, we'll see advances in terms of style, desirability, range and technology," he said. "As a result, earlier models will become increasingly affordable. Simultaneously, as new sales go up, so will used sales. As growing demand pushes up production volumes, economies of scale will see a corresponding drop in price."

For Will Craig, founder and MD of LeaseFetcher, a car leasing comparison website, AFVs are already becoming increasingly affordable with long-term running costs massively counteracting the purchase price.

"I do believe that it is a case of supply and demand -

manufacturers will feel the pressure to create cheaper EVs to meet a new, ready-made source of budget-conscious customers," he said "The need to abide by the law will push up sales. And this roaring demand will then see a drop in prices in the long-term as EVs become the norm."

Eben Lovatt, CEO of car leasing comparison website Moneyshake, believes charging point infrastructure will play its part in the affordability of AFVs, a factor addressed by the government in its Road to Zero Strategy.

The strategy's numerous pledges include a £400m Charging Infrastructure Investment Fund and a commitment to charging points for new houses, motorway services, workplaces and even in lampposts.

The upcoming switch from diesel and petrol is in part motivated by a pressing need to reduce greenhouse gas emissions and emissions of particulates that are injurious to health. The switch also provides the UK with an opportunity to get ahead in a global market estimated to be worth over £1.5 trillion a year.

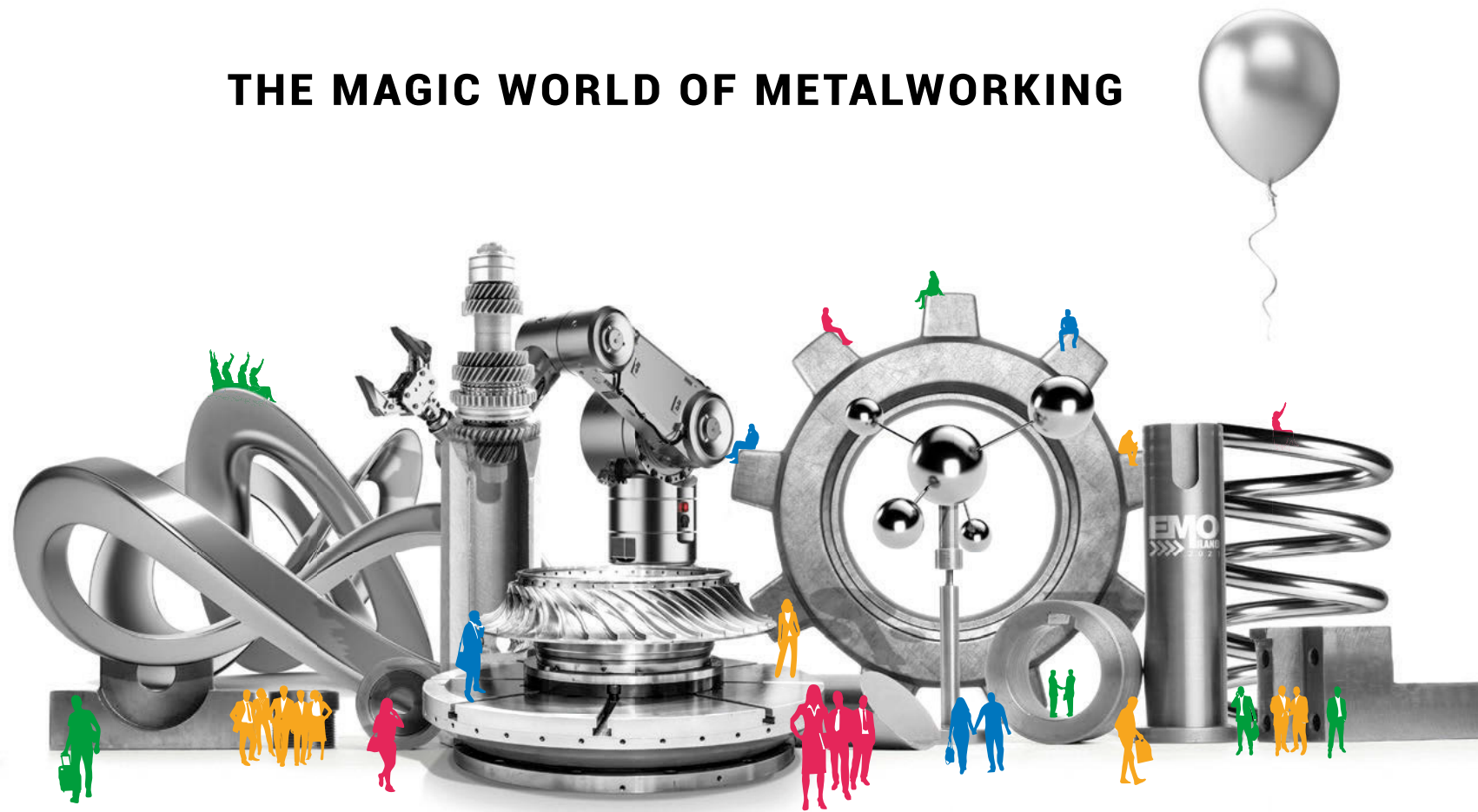
"Just like progressive countries such as Norway, Denmark and Iceland, forward-looking manufacturers are seeing this change as an opportunity and new economy," said Morris. "Think of smart phones, the internet, fast food delivery, Uber, Amazon - all new, all disruptive and all now accepted and pervasive. The established fossil fuel and automotive manufacturing industry have had a good run but will need to adapt to survive. They have done so before with safety and combustion emission limits and will do so again." **ENGINEER**

// THE NEED TO ABIDE BY THE LAW WILL PUSH UP SALES AND THIS ROARING DEMAND WILL SEE A DROP IN PRICES AS EVS BECOME THE NORM //

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CRATE EXPECTATIONS

As our streets become ever more clogged with delivery vehicles, the race is on to transform the world of last mile delivery. Andrew Wade reports.

Western society is currently experiencing a crisis of conscience versus convenience. The boom in online shopping, food delivery platforms and new mobility providers has made it easier than ever to get what we want and where we want, around the clock. This ultra-convenient consumerism comes at a cost, however, and the streets of our cities are clogging like arteries exposed to a few too many takeaway pizzas.

Autonomous delivery systems of different stripes are emerging to help solve this logistical conundrum, from underground hyperloops for distance freight, to robotic drones that service the all-important last mile. Starship Technologies falls under the latter category, its six-wheeled robots delivering groceries, hot food and packages to customers on demand. When The Engineer first spoke with the company back in 2016, its bots had covered just 5,000 miles in testing. Four years later, things have moved on quite a bit.

"We're over 350,000 miles travelled now," said Henry Harris-Burland, VP of marketing at Starship.

"One of the biggest differences is that we weren't a commercial service back then. We were probably doing testing, we may have been doing one or two deliveries for a couple of partners, but it's a complete transformation. We've done over 100,000 autonomous deliveries now, 5 million road crossings. We're doing something like 10-15,000 road crossings every day with our robots."

Starship's robots travel at around 4mph on paths and across roads, sharing the space with - and giving way to - pedestrians. They use a combination of

machine vision and GPS to navigate, building up a richer picture of their environment over time. Appearance wise, the robots haven't changed much since when they were testing in Lewisham four years ago, but there have been incremental upgrades in the hardware, as well as major software and battery advances.

"We do have new cameras," said Harris-Burland. "There's 10 cameras instead of eight cameras now. There's all sorts of sensor fusion that we didn't have previously."

"The batteries have changed as well. Previously we had batteries that were running maybe three hours. Now we've got batteries that last all day, 18 hours or more."

On a particularly busy day, the delivery bots can cover up to 50 miles on a single charge. It's this improvement, combined with the leaps in autonomy, that has underpinned Starship's rapid commercial expansion.

"That's where the improvements have come, in the autonomous driving, in the machine learning," said Harris-Burland. "In our understanding of 'Is that a trash can? Is it a bicycle? Is it a pedestrian?'"

Four years ago, the company was partnering with food platforms like Just Eat. Today, it operates its own platform that third parties sign up to. For example, in Milton Keynes you can go on to the Starship app and order groceries from Tesco or Co-op, or food from Frankie & Benny's. When the robot arrives to the designated drop-off around 30 minutes later, the customer uses the app to unlock the lid and retrieve the order.

"We're talking about hundreds of deliveries a day in Milton Keynes," Harris-Burland explained. "Thousands and thousands of customers. Something like more than 75 per cent of the entire area that we operate in has had a robot delivery."

Though Milton Keynes has been a major neighbourhood success, the biggest market is the US, where Starship robots can be found across eight university campuses and one corporate campus. The company is also operating on industrial campuses in Germany and Denmark, as well as a neighbourhood in Tallinn, Estonia. In all these locations, says Harris-Burland, social



**// AUTONOMOUS DELIVERY
SYSTEMS ARE HELPING TO
SOLVE OUR GROWING LOGISTICS
CONUNDRUM //**

↑ Magway's hyperloop inspired technology uses linear motors to propel crates along a network of pipes



acceptance comes easy once the initial novelty wears off.

"It's just commonplace in the areas that we operate in," he said. "They're seen every day, out in the public, on the sidewalks on pavements, and they've been embraced universally, which is one of the most important things for us."

It's perhaps an indictment of human nature that one of the first questions people ask is how often the bots get stolen or vandalised. On college campuses in particular, one might envision the diminutive bots on the receiving end of some varsity hijinks.

"We have had incidents," Harris-Burland admitted. "But we feel comfortable with where we're at right now, because no one has managed to steal one or anything like that. There's alarms if you pick it up. As soon as you pick it up it's like a screeching car alarm going off."

Part of the company's sell has been the potential impact on congestion and pollution. Not every robot delivery is necessarily replacing a car journey, but Starship's neighbourhood operations in particular can alleviate the need to jump in the car for that pint of milk or those emergency baby wipes.

Autonomous delivery could help cut car journeys as well as reduce the number of delivery vans servicing the last mile. When it comes to moving bigger quantities of goods over greater distances, however, 4mph robots aren't a good fit.

Magway is a UK company hoping to fill that middle ground. Inspired by Hyperloop, it plans to use linear motors to propel crates - or totes - of goods on a nationwide network of pipes, reducing HGV freight traffic. It recently raised over £1.5m through crowdfunding, more than doubling its original target. According to co-founder and technical director Rupert Cruise, the concept has struck a particular chord with younger people.

"53 per cent of our investors are under 30," he told *The Engineer*. "So we're definitely speaking to the younger generation. And just over 70 per cent are under 40."

"We also won a £1.9m government grant in December, which kicks off on the first of March. Those two pots of money give us a runway basically for the next two years."

Unlike Hyperloop, Magway's technology doesn't require a vacuum, propelling its freight at a relatively sedate 54 km/h. Precision control of the linear motors allows totes to travel just fractions of seconds apart. This gives the network extremely high carrying capacity, even with the relatively low speeds.

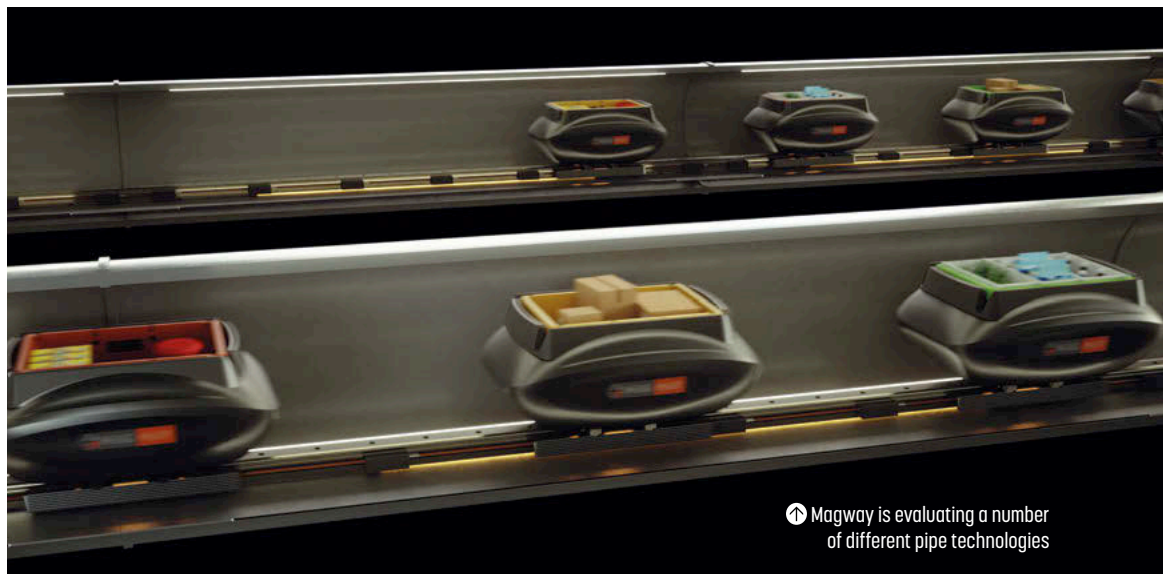
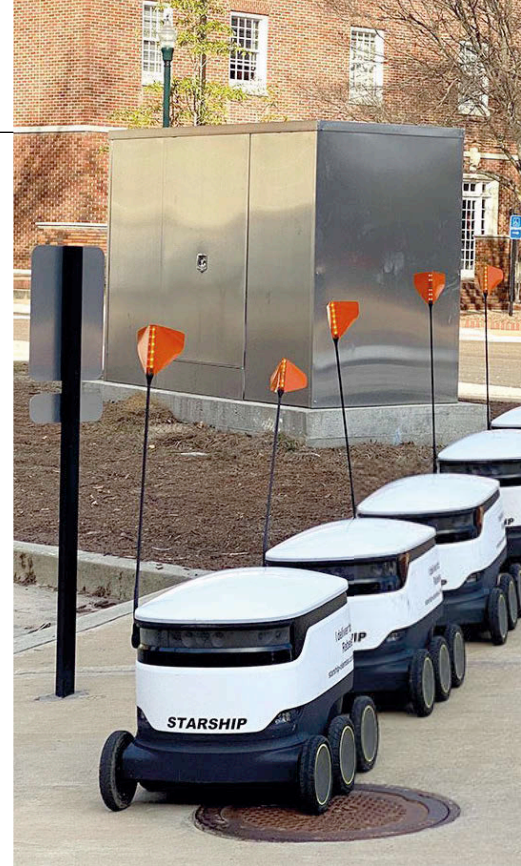
"We've got phenomenal results from our demonstrator," Cruise explained. "We've only got a short section of track within our test facility. The total length of the track is only 12 metres. We're able to accelerate the system up to 8m/s safely, and have it running in both directions. The rate of acceleration - though we wouldn't ever do this on the full-scale system - is equivalent to a high-performance motorbike."

The recently secured funds will help finance a 1km development loop, with prospective sites being explored at



the Olympic Park as well as the MTC in Coventry. Beyond that, the company has plans for a commercial pilot and is seeking to partner with an airport, where logistics operations are often highly time sensitive and high value. An airport pilot would probably not require much, if any tunnelling. If Magway is to take its solution nationwide, however, some major digging is likely to be required.

"One option is to run pipes along the surface, and that's clearly the cheapest option," said Pierce. "But all of our costing has been done around what we call shallow build systems, which is a cut and cover system. The pipes would come with the track pre-inserted, in 12 metre sections. They connect together and we would sling all of that a kilometre at a



Magway is evaluating a number of different pipe technologies

// THE RATE OF ACCELERATION - THOUGH WE WOULDN'T DO THIS ON THE FULL SCALE SYSTEM - IS EQUIVALENT TO A HIGH PERFORMANCE MOTORBIKE //

time into the trench."

According to Cruise, there are also a number of promising pipe technologies emerging that could dramatically speed rollout. In Australia, a company called Long Pipes Ltd is essentially printing pipes in a fabric-type material, which is then inflated and cured using resin to produce a continuous length of pipe with no joins, and no need for welders. It's in

the early stages of development, but the technology could someday be adapted for the type of large-scale rollout that a Magway network would require.

"We can lay about 200m per day of pipe," said Cruise. "Long Pipes, depending on the terrain, can lay between 2-6km per day. It's phenomenal technology."

Where deeper sections are required, Magway will look to established tunnel boring techniques, combined with automatic track laying. These methods will mean the tunnels will only be accessible at either end, raising the inevitable question of what happens when something goes wrong. It's a question Cruise hears frequently. He understands the concerns but says



“Our manufacturing partner supplied linear motors to Disney 30 years ago, and they’ve never had a spare,” Cruise said. “One of their motors has been underwater for 20 years, never had a spare. That’s how resilient they are.

“The wear element is the wheels, but they go in and out of the pipe, so we can always replace them every few years. Whereas the tracks, we don’t want to wear, because everything we put in the ground, we don’t want to see again for another 40 or 50 years.”

For a Magway network to be effective, it will have to integrate with major retailers and distributors like Amazon and Ocado, both of which are

// YOU HAVE THE POTENTIAL TO GO FROM PLANT TO KITCHEN TABLE IN TWO HOURS //

already fully embracing the frontiers of automation. Indeed, Ocado was a partner with Magway for one of its earlier Innovate UK grants and retains an interest in the company. According to CTO Paul Clarke, Ocado’s trunk and last mile deliveries are simply important pieces in a larger logistics puzzle. “Nothing for us in the last mile would work if we didn’t have that amazing precision upstream,” he told *The Engineer*.

As an online-only operation, Ocado relies on the doorstep interaction more than any other supermarket. This of course raises the question whether autonomous deliveries would ever be desirable for a company that places such emphasis on that point of contact.

“A typical Ocado order is 50 items and customers really value us bringing that into their home,” said Clarke. “That’s a premium service, in that it sets the bar high for others in terms of what last mile delivery means...getting to the curb is important, but we want to be able to get from the kerb to the kitchen table.”

In its relentless pursuit of optimisation, Ocado has always turned to data, from route efficiency and van speeds to warehouse forecasting and robotic picking. But when it comes to autonomous delivery, data is hard to come by, with high stakes and heavy regulation inhibiting the scale of testing one might desire. Simulation has a role to play, says Clarke, but sooner or later you have to get your feet wet.

“There’s a tendency for people to stand around swimming pools trying to learn how to swim the Atlantic,” he said. “We’re going to have to find other ways to learn.”

One of the ways being looked at by the company is a ‘living labs’ model, whereby day-to-day operations coincide with a type of real-life beta testing.

“For example, our first-generation warehouse in Hatfield has been a living lab,” Clarke explained. “It’s shipped millions of customer orders over the years, but it’s done that while we’ve ruthlessly continued to invent new mousetraps, new ways of doing what we do.”

A new project will replicate this model on a much wider scale, first on a business park, then countywide across Hertfordshire. It will look at the intersection of autonomous vehicles, drones, robots, smart infrastructure and smart services. A consortium led by Ocado will start off on semi-familiar territory, moving groceries autonomously, but will also look to move people.

“We eventually want to take that off the park and out to a county level, turning Hertfordshire into a smart county,” Clarke explained.

The ultimate plan is for the project to become a steppingstone towards smart cities, where Ocado and its partners can learn on the job and scale up as they go.

“It’s not some sort of theoretical set-up,” said Clarke. “On that park we have a hospital, Ocado head office, the first Ocado warehouse, a University of Hertfordshire engineering hub, residential property, a school. And that creates a rich ecosystem for this experimentation.”

Last year the company launched Ocado Zoom, a rapid grocery delivery service based around its Acton warehouse in West London. It offers customers a choice of more than 10,000 items, delivered in under 60 minutes.

“Typically, it’s actually below half an hour even 20 minutes,” said Clarke.

Further down the line, Ocado Zoom could be co-located with vertical farms and industrial kitchens, getting ultra-fresh produce and cooked meals to customers in record time. Coupled with a green logistics infrastructure, it’s a system that could deliver on both conscience and convenience.

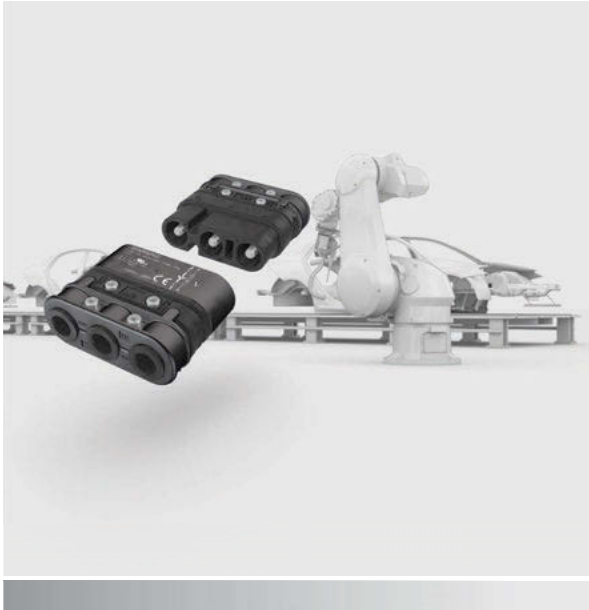
“Now you have the potential to go from plant to kitchen table in maybe two hours,” said Clarke. “And that is freshness that, unless you live on a farm, you will never experience. That’s a properly interesting, integrated food machine, from growing to last mile logistics.” #ENGINEER



the system will be designed with both resiliency and redundancy.

“Step one is we always have two pipes,” he explained. “Step two is that we will always interconnect those pipes every kilometre, so if there is an (outbound) blockage, the outbound traffic can be rerouted. Vehicles can also travel both ways in the pipe. So if there’s a blockage we can actually reverse out and vacate the pipe.”

Robotic vehicles will also be used to sort blockages. Where robots can’t solve a problem, sections of pipe can be dug up for repairs to take place. But if the system works as planned, that type of intervention will be extremely rare. The linear motors, in particular, are built to last.



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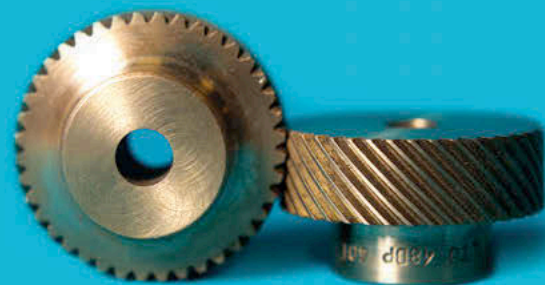
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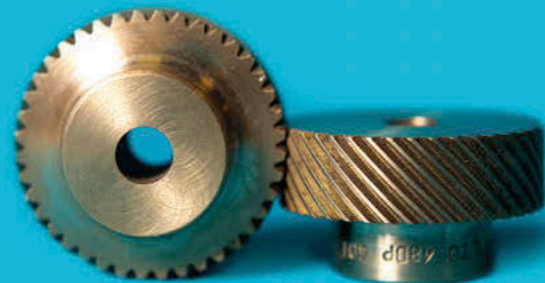
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Last-mile delivery: the challenge for logistics providers

Dr Tom Cherrett, Professor of Logistics and Transport Management at the University of Southampton and Dr Julian Allen, Senior Research Fellow at the University of Westminster and the Centre for Sustainable Road Freight

The rapid increase in online shopping is resulting in several new challenges. The parcels, packages, groceries, and hot meals ordered online are resulting in a growing number of last-mile deliveries to customers, using a wide range of vehicles that use road and kerbside space, contributing to air pollution and greenhouse gas emissions. Over-time, online retailers are offering customers ever-faster delivery options, with same-day and instant delivery offers becoming ever-more common, with a consequent reduction in freight transport efficiency.

In their efforts to generate sales and gain market share, many online retailers entice purchases with discounted prices and so-called 'free deliveries', with many consumers citing 'free delivery' as a major factor in their purchasing decision. Some last-mile parcel deliveries 'fail' when no-one is at home to receive them, requiring redelivery on a subsequent day and rates of returns, particularly linked to clothing purchases are increasing, generating more transportation. Other issues linked to the rise in online shopping include the increase in self-employed and casual delivery and warehouse work, and an increase in the closure of physical stores, with many high streets becoming run-down.

Work we carried out in the FTC 2050 project (www.ftc2050.com) has provided various insights into the key role that engineers can play in helping design and manage our transport and computing environments to better cater for the growth in last-mile deliveries. Our research has indicated that in dense urban areas, 'portering' (the carriage of freight by people



DR TOM CHERRETT

// DELIVERY COMPANIES SHOULD CONSIDER NEW BUSINESS MODELS IN WHICH THEY COLLABORATE WITH EACH OTHER //

on-foot) and cargo cycles, once a mainstay of delivery systems before the advent of the combustion engine, should be re-visited as sustainable solutions. This requires companies to re-engineer their delivery systems using logistics hubs and mobile depots (i.e. trailers used as storage locations) positioned close to delivery catchments to make these modes operationally viable. In addition, delivery companies should consider new business models in which they collaborate with each other in congested urban areas to reduce total vehicle activity and its impacts, as well as their

operating costs.

In general delivery companies and retailers should make use of computing technologies to assist drivers and provide customers with up-to-date delivery information. Retailers should also reconsider their delivery options to provide customers with slower, more sustainable delivery options to improve load consolidation, as well as enhanced systems for both providing goods to customers using collection points and locker banks, as well as using these facilities for improved goods return. The challenge is to understand where to locate such facilities in order to best serve consignees in the



DR JULIAN ALLEN

// DROIDS ARE LIABLE TO CONFLICT WITH PEDESTRIAN ACTIVITY AND MAY BE BEST SUITED TO INDOOR ENVIRONMENTS //

surrounding area, and the operating attributes of these facilities.

Policymakers can support and plan the land and building requirements of facilities that make last-mile logistics more sustainable (such as logistics depots and hubs, vehicle storage and recharging locations, collection points and locker banks). They may also need to take action if retailers persist in offering delivery services that do not reflect their full internal and external costs. Urban traffic authorities can also investigate how kerbside space can be more equitably shared between logistics providers and other users through automated and smart booking systems.

Vehicle manufacturers have an important role to play in terms of providing a greater range and quantity of clean last-mile delivery vehicles. Unmanned aerial vehicles could also assist in rural last-mile logistics and the movement of critical items such as medical supplies, but face challenging barriers in terms of safety and security in urban areas. Similarly, the on-going development of droids are liable to conflict with pedestrian activity in busy locations, and may be best suited to indoor environments (in offices, factories and warehouses). Recent research has indicated that as autonomous road vehicles become available, they have the potential to be used in conjunction with the on-foot porters previously described.

Consumers concerned about last-mile sustainability can also make a difference by using retailers that provide 'green' delivery options, selecting the least transport-intensive when placing orders, and being sufficiently patient to wait for all the items in their orders to arrive in a single delivery. #ENGINEER



IN OUR OPINION

Aviation's zero carbon balancing act

Are the aviation sector's zero carbon ambitions compatible with continued growth in the number of flights, asks Jon Excell?

Last month (Feb 2020) Sustainable Aviation, an industry group whose members include a number of airlines, airports and manufacturers such as Rolls-Royce and Airbus announced a pledge to cut net carbon emissions to zero by 2050.

This would be a notable enough aim taken in isolation, but the group claims that the sector will be able to achieve this despite a planned 70 per cent increase in the number of flights over the next three decades.

Aviation is currently responsible for between 2 and 2.5 per cent of global man made CO2 emissions, a relatively low figure when placed alongside energy and heat production (which accounts for around a quarter of GHG emissions) but one which conventional wisdom dictates will grow as passenger traffic rises.

The sector has been trying to marry the apparently mutually exclusive aims of continued growth and reduced emissions for a number of years now with initiatives such as the EU's Clean Sky project, which was launched back in 2008, driving investment in

technologies that can deliver more environmentally friendly aircraft.

But the latest pledge - which replaces a previous pledge to halve emissions by 2050 - marks a significant ramping up of the sector's ambitions.

The group's announcement has been met with incredulity by some. Greenpeace has dismissed it as "greenwash", whilst campaigning group AEF questioned industry's commitment to the new targets. "The aviation industry likes to set targets," said its director, Tim Johnson, "but so far has successfully resisted being held to account for delivering them."

But Sustainable Aviation is bullish on its chances of meeting the goals, and claims that through a mix of new technologies, increasing use of biofuels, and aggressive carbon offsetting measures, it will be able to rise to the challenge that it's set itself.

There's certainly no doubt that technology can play a role in improving the overall efficiency of aircraft. Since the advent of jet technology, the carbon dioxide emissions produced by aircraft engines have reduced by 80 per cent, and ongoing refinements to turbine engines continue to deliver once-unthinkable improvements in efficiency. To

give an example, Rolls Royce's Trent XWB is thought to be as much as 10 per cent more efficient than earlier generations. The firm's Ultrafan engine, which is currently under development, will use lightweight carbon fibre blades to deliver even greater levels of efficiency.

Meanwhile, ongoing developments in hybrid electric propulsion systems - now an active area of research for most of the major aerospace organisations - could play a key role in further reducing the emissions of next generation aircraft.

But whilst all of these measures can contribute to an improvement in performance and efficiency for aircraft, are they really going to make an impact on the bigger picture whilst the number of flights continues to grow?

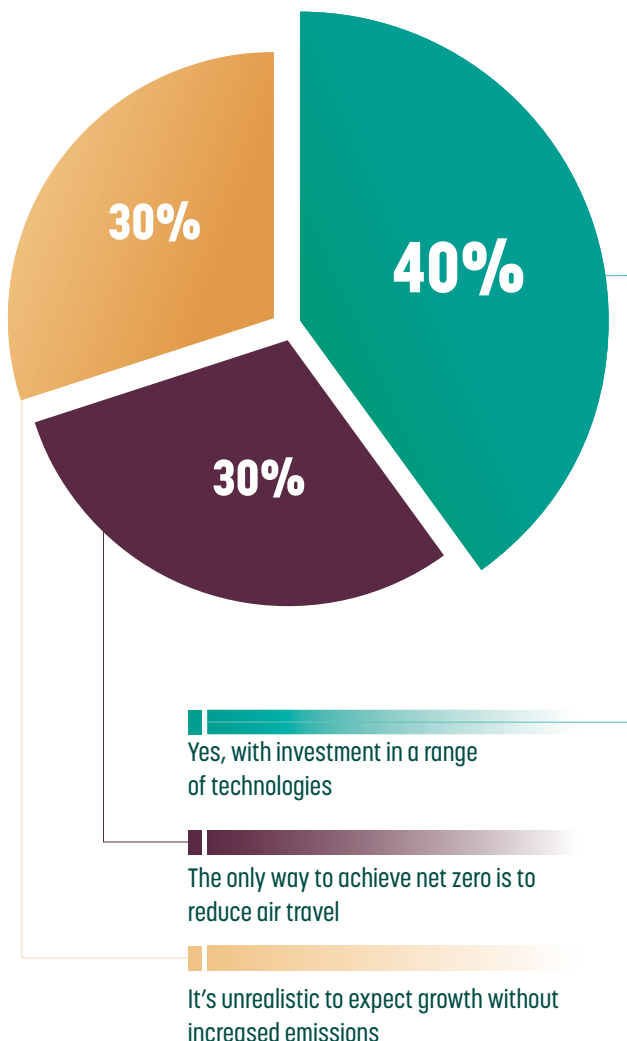
Perhaps ultimately we are faced with a stark choice. Either we accept aviation's increasing environmental footprint as the price we pay for the luxury of flight, or we drastically reduce the number of flights we take and turn back the clock on a century of globe-trotting. **THEENGINEER**

Poll: can the aviation sector cut CO2 emissions without restricting growth?

In our poll on the subject, which received 428 votes, readers were divided on whether or not the aviation sector can balance its zero carbon ambitions with continued growth.

40 per cent of respondents - the largest response group - were positive about the sector's prospects, and said that with the right investment in a range of technologies growth and carbon reduction would be compatible.

The remainder, however, were less convinced, with 30 per cent claiming that the only way to reduce aviation's environmental impact is to reduce air travel, and the remaining 30 per cent simply stating that it's unrealistic to expect growth without increased emissions.



IN YOUR OPINION

I think aviation can adapt and being a contributor of just 2.5% emissions, at least should earn the benefit of the doubt that it can adapt. A change in attitude could help that, i was fiercely defending my return flight holiday to Rome when I found the person opposite me at work took 4 return business class trips to Australia on behalf of the company...that does seem excessive
Richs

Aviation certainly needs to cut back on emissions and this could be achieved by further improvements in engine design and operation, better aerodynamics and weight reduction. Extensive taxiing at airports could be reduced using tugs but this could also cause complications and would need clever scheduling and asset planning.

The great and the good of the green brigade seem to have got it in for aviation, deep sea maritime transport and land transport Are we to revert to sailing barques, quinqueremes and bullock carts?

Phil Mortimer

Apparently Bullock Carts are out - because of methane emissions from the bullocks backside.

Honest Joe

It is well known that when governments legislate , industry will invent and do the research and development to meet the legislation. It is also well known that industry will protest and say the legislation is not achievable, and use the argument, of lost jobs, closure of factories etc.. The simple fact is that now industry can spend the money, do the R&D and it will benefit from being a market leader, with all the prosperity and financial gains that will follow. To achieve the requirements of aircraft on CO2 it may be going back to a propeller driven by an electric motor, with the electricity coming from batteries and solar

panels covering the wings. There are many alternatives but first you have to start looking.
John Patrick Ettridge

More than any other mode of transport - road, rail or maritime - power/weight ratio is crucial for aviation. Batteries have only about 2% of the energy density of hydrocarbon fuels; biofuels can do much better and biofuel use should be prioritised for aircraft.

Trevor

I am very suspicious of bio-fuels - as it often means (for power generation) food crops and/or carbon sinks (such as forests) are removed - thus reducing natural carbon sinks. Reforestation takes time to obtain the mature trees (30 years or more) - so needs to have started already! And there has been no indication of how many/area trees are required to sink CO2 produced by flying planes. Using hydrogen fuelled engines (like Skylon) - though the low power bulk density of liquid hydrogen is a major issue, I suspect. It would be interesting to see how issues with hydrogen leakage etc.. might be addressed. But sounds do-able. Light weighting of materials (not the same as just using crude composites) might reduce but certainly would not eliminate CO2.

Perhaps power beaming would make electric aircraft an option? Though I am aware of no scoping studies (except for some work done in the 60s). My favourite, if the numbers look right might be reforestation e.g. on UK hills - that were, originally fairly wooded and now are marginal or livestock only (which could benefit from forestation). But, again, it would help if the aviation industry would give us the figures...otherwise who would believe that they were serious!?

Peter Spence

Unfortunately we have more commentators saying what we cannot do, instead of those that say what we can do. It wasn't long ago that the mobile phone had many limitations, but today your mobile phone is virtually a mobile computer, and does much more than even considered possible ten years ago. So instead of focusing on what you cannot do, put the money into R&D and provide the answers, Someone will provide the answers, so why not a British inventor or company ?
John Patrick Ettridge

HAVE YOUR SAY
Visit our website to take part in the continuing debate on this emotive topic



A bridge too far?

Boris Johnson's announcement that he's considering plans to build a bridge between Northern Ireland and the UK mainland received a mixed reaction



✉ Build it. Show the rest of the world we have the best engineers and capability. Denmark to Sweden across difficult waters was a success. Why not this bridge?

Bruce Ellison

✉ In principal it would be great if it could be built. Apart from the significant depth of water and lack of sufficient infrastructure at either end - especially if the Argyll

route is under consideration - the tidal flows and swell, and Atlantic weather will have a significant impact. **Nick Cole**

✉ This is yet more flawed, nonsense from the Tories, proposing to spend billions on a bridge no one wants - will it link up with the £100Bn+ HS2 London to Birmingham shuttle that no one wants?

✉ By all means let's spend big money on big infrastructure

projects, but ones that the country needs: national railways upgrades, hospitals, nuclear power (SMRs), for example. **Another Steve**

✉ What problem is this bridge to solve? What is its purpose? What are the pros & cons? Can the cost, risks, hazards, be justified? I don't hear the politicians discuss these important considerations, despite these being exactly what politicians should be debating about a huge engineering task such as this. **Steve Monaghan**

✉ My quick back of an envelope calculation, based on the Strait of Messina costings and various tunnels and inflation, puts a Scotland/N Ireland bridge/tunnel combo at £35bn minimum, as long as you keep the usual suspects from putting their snouts in the trough. Is it worth it? That is for others to decide. **JohnHartley**

✉ 'Let's have a bridge connecting us to Northern Ireland' said no-one in Scotland ever. How about those 40 odd hospitals instead though, Boris? **Richard Mills**

✉ While it may seem a good example of 'out of the box thinking' one must ask whether there could ever be any hope, of even slightly justifying the cost of such an engineering 'folly'. **Alien Alien**

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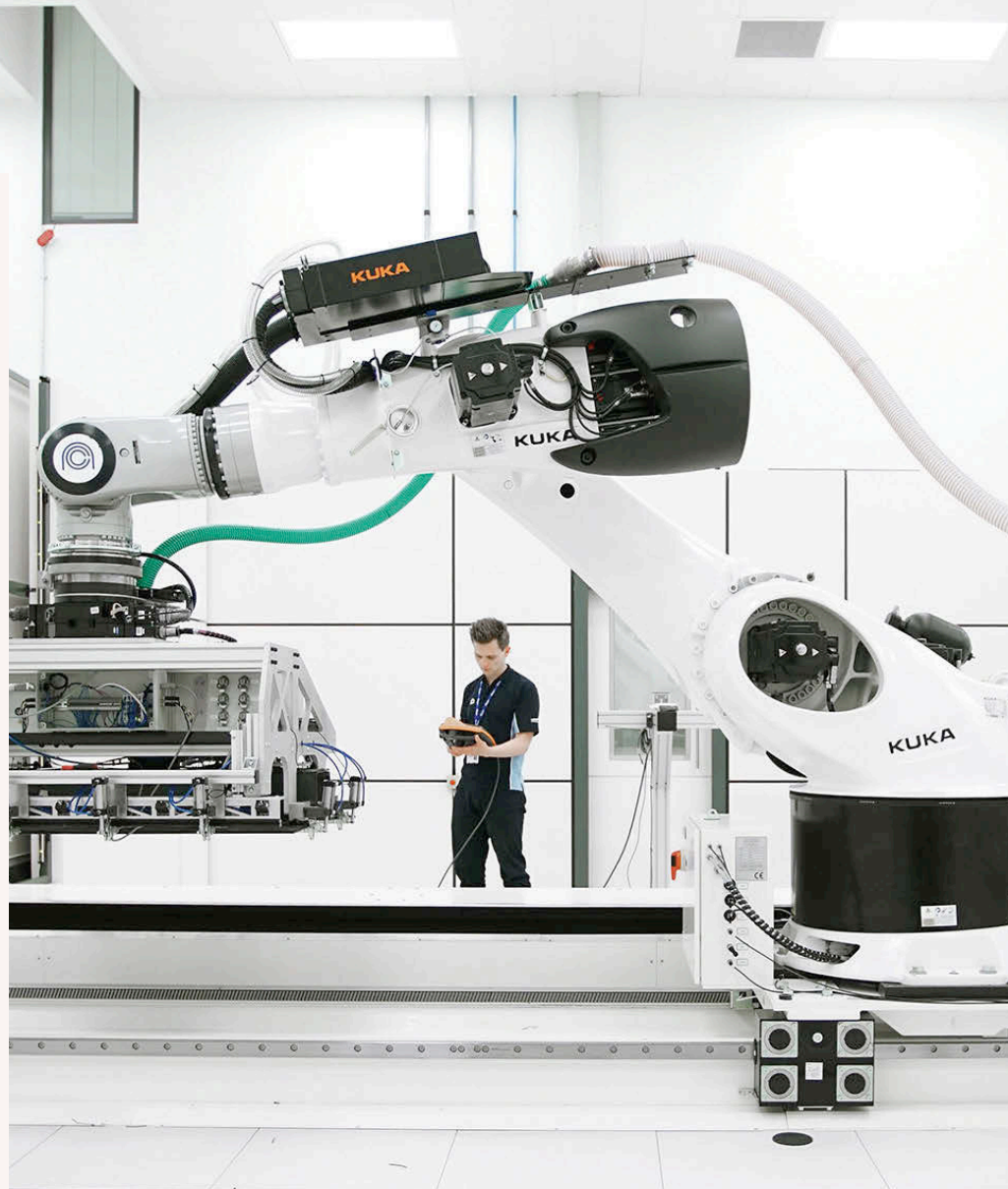
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KNITTING TOGETHER THE DIGITAL THREAD

An expert panel explored the practical challenges and benefits of tracking an asset's digital journey from inception to end of life.

JON EXCELL AND ANDREW WADE REPORT

Given the degree to which digitalisation dominates industry discourse, it's easy to forget that so-called digital tools and processes have been a feature of manufacturing for many decades.

From the CNC machines and computer aided design (CAD) tools that began to proliferate from the 1970s, to the more recent introduction of enterprise-wide product lifecycle management (PLM) tools, digital innovations have been compressing design, streamlining manufacturing and boosting productivity for many years.

But such tools are now just the tip of the digital iceberg. Today, advances in the way we capture, analyse, and share data are leading firms to think not just about how digitalisation can improve one step of a product's journey but how it can be used to create an all-embracing digital framework, or, to use the current buzz-phrase, a digital thread, that provides a holistic view of an asset's data across its entire lifecycle: from design and build, through in-service operation, and finally to decommissioning.

The advantages of such a joined-up approach are compelling: enhanced productivity, improved maintenance cycles, optimised operation, and a continuous virtuous loop of information that can be used to refine design processes and optimise manufacturing.

But whilst the benefits are easy to imagine, they're not so simple to attain in practice. In fact, in a world where

supply chains are complex, where cross-disciplinary teams are common, and where the sharing of data and IP doesn't always come naturally, embracing the digital thread is a mind-bogglingly complex problem.

Earlier this year (January 2020) *The Engineer*, in partnership with engineering services giant Babcock International, brought together a panel of experts to explore the benefits and the potential of the digital thread, to examine some examples of the digital thread in action and to consider some of the obstacles and challenges to its deployment.

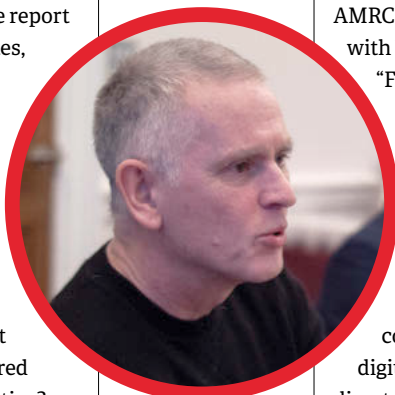
As our panel found, and as the report over the following pages illustrates, whilst there are already some compelling examples of the digital thread in action, there are still many questions. Questions such as is there a greater requirement for open standards? How do you take sceptical members of your supply chain with you? And what technologies and skills are required to put the digital thread into practice?

What is a digital thread?

Setting the scene for the discussion, Babcock's engineering and technology



Chris Geaves, Head of Group IMG & Factory 2050 AMRC



Prof Dave Robertson, University of Edinburgh

director Neil Young kicked off with a pithy definition of the concept, and an explanation of why it's important to the company. "In all of our sectors, Babcock as a business gets involved in the full lifecycle of an asset," he said, "whether it's the original design, through to the building and manufacturing of that asset, through to the operations, the in-service support and maintenance and all the way through to the dismantling of the product."

Young said that this data sharing from one stage of the lifecycle to the next has largely been a paper-based process traditionally, but that being able to share this information digitally - thereby ensuring it's available and useful at every stage of an asset's life - has been critical to helping make key decisions in the lifecycle of the warships, submarines, nuclear power plants and other critical assets for which the firm is responsible. "All are very critical and complex assets - how do you make sure you're making the right decision at every step of the lifecycle - they must be safe, they must be efficient and they must do what the client wants them to do in every single application."

Chris Geaves, who heads up the AMRC's Factory 2050 operation, agreed with Young's take on the definition. "For me, it's got to be about the cradle to the grave of your product, involving your supply chain, your customers, it's through-life engineering and it's end-of-life engineering," he said.

The panel was also reasonably aligned when considering the benefits of a digital thread. Siemens digital director Brian Holliday put it succinctly when he said it's about removing the risk of information loss. "For me the digital thread removes the inherent information loss you get when you transition from design, to making something, to operating something," he said. "It's about stopping information loss in the first instance, and then building an information set that helps improve your ability to predict things or

// IT'S GOT TO BE ABOUT THE CRADLE TO THE GRAVE OF YOUR PRODUCT, INVOLVING YOUR SUPPLY CHAIN, YOUR CUSTOMERS //



into a deeper digital relationship.

In parallel with this approach, Holliday suggested that there may be some value in mandating digital thread buy-in before contracts with suppliers are signed, although he conceded that “it might be painful to start with.”

Business and economic benefits

One key benefit that several of our panellists alluded to was the ability to have a variety of perspectives across a unified set of data. A digital thread for a complex asset can be interrogated in different ways by different departments, depending on the desired goals.

“Obviously for Type 31 we’ve got a big digital shipyard project happening in Rosyth,” said Neil Young. “What we’re saying is we want one set of data, but the engineer will look at it one way, the supply chain will look at it another way, and have different information to look at and reports coming back.”

Those multiple perspectives will extend to the customer as well. For an asset like the Type-31, the digital thread will provide insight into the various different roles that the frigate will fulfil, beyond its basic functionality as a Royal Navy warship.

“They want something that floats and can move, obviously,” Young continued. “But they also want it to do specific capabilities, whether that’s disaster relief one day, or pa-trolling the Straits of Hormuz the next. That end user experience is the important thing...and the digital thread will feed back into that →



➤ Prof. Graham Wren, Strathclyde University

to improve them when you go back.”

Expanding on why this is important, Babcock’s head of innovation & technology Malcom Lee said: “If you have a digital thread, if you’re able to maintain the continuity of that thread every time it passes an interface, it saves a huge amount of time, effort and money.”

Another key benefit identified by the panel, is the way in which a digital thread can drive improved dialogue and collaboration throughout the supply chain. “When we have goods being delivered to us, we know the quality records of that already,” explained Young. “They’ve been tagged at the supplier with the right coding, they arrive into our stores, and our stores can scan that particular item, we know exactly which compartment of the ship it’s going into....it’s a much more joined together solution. And it’s not about holding the supply chain at arm’s length. It’s about bringing the supply chain into our system and integrating them much more so that they have better information.”

Despite the clear benefits, panellists

agreed that getting the supply chain on board isn’t always easy. “One of the challenges for the thought leaders like Babcock is getting the supply chain to see the vision of how it helps them,” said Strathclyde University’s Graham Wren.

Young agreed that clearly articulating the benefits to suppliers is a challenge, and that organisations like Babcock have a role to play in educating suppliers about the long-term benefits of entering

WEAVING A DIGITAL THREAD

➔ When it comes to data collection and digitalisation, automation should be the rule rather than the exception

➔ Good data collection is essential, but it’s when that data is fed back to improve the asset that the real value is derived

➔ Go slow to go fast. It’s better to bring everyone along the right path together than move too quickly and leave parts of your organisation behind.

➔ The ability to clearly articulate the benefits of a digital thread will help bring stakeholders onboard

➔ Make sure your processes are in good shape before you digitalise. A bad digital process is still a bad process.

➔ Highlighting the economic impacts will be essential for securing executive and government backing

➔ Don’t be afraid of the challenge. The change is coming and those who embrace it will benefit.



to make it better.”

Brian Holliday agreed, pointing out the different requirements of different stakeholders in any given asset. Factory owners may focus on the input and output processes of a given machine, while the suppliers of that asset might be more concerned with its performance relative to other machines.

“This notion of multiple lenses into the same digital thread is an interesting issue,” said Holliday. “We shouldn’t gloss over the fact that there is inherent complexity in that but there is utility too.”

That utility on a company level should be relatively apparent, but the benefits to the economy at large could be more difficult to articulate. He pointed to an estimate from Made Smarter of a £455bn macroeconomic boost to manufacturing over a ten-year period, based on widespread adoption of industrial digital technology.

According to Cranfield’s Dr John Ahmet Erkoyuncu, some of the benefits will come from entirely new business models that digital threads will enable. “If you’ve got a digital thread, you have a lot more understanding of the asset, how it’s performing, he said. “And this means you can move more towards capability-based solutions.

It could also have significant impact in terms of business models. You could perhaps even sell your digital thread in a licensing-type approach.”

Harmonisation & Open Standards

Our panellists all agreed that open standards and harmonisation will be key to widespread adoption of the technology. “There’s certainly a role for standards in this,” said Malcolm Lee. “From a Babcock perspective we promote open standards and architectures as being very much a key component of this because that is the thing that allows widespread sharing. If you start to have proprietary standards it

can make it very difficult for others to utilise the thread.”

“Openness is key,” agreed Brian Holliday, adding that this also opens up digital thread innovation to smaller organisations. “No one company can solve digital, Ecosystems are key, building platforms where a small company can solve a problem in an app with a low code approach that instantly becomes available globally, we don’t think anything of that in our consumer lives but in industry we’ve been that little bit behind. The ecosystem’s key in that the little integrators can now solve problems that in the past we though needed an IBM or Siemens.”

Lee added that open standards will also make it easier to add to the thread at future points in time. “If the standards are open the ability to weave in an additional part of the thread at a future point in time...is manageable. As soon as you start to have closed or proprietary standard you can very quickly run up against economic hurdles...where the cost of the software and the tools required become prohibitive. That’s why we see the open standard as critical.”

Machine learning and AI

Given the huge volumes of data involved, there was widespread agreement amongst the panel that machine learning and AI would play a pivotal role in enabling digital threads.

Graham Wren said that rather than taking humans out of the loop completely, AI should enable better decision making. “Rather than humans poring over endless data, the machine can take you to where you add the most value and provide the most impact to the project,” he said. “The more data you can add to that from similar devices, the greater the accuracy



Dr John Ahmet Erkoyuncu, Through-life Engineering Services Centre - Cranfield University



Neil Young, Engineering & Technology Director, Babcock International



becomes.”

Edinburgh University’s Dave Robertson sounded a note of caution however, pointing out that digitalisation had the potential to complicate as well as enhance: “A lot of this complexity is because a lot of those kind of tools all got mature at a similar point in time – everywhere you look there’s some damn digital thing that you can then use to possibly make your life better but certainly make your life more complex with data. That’s the Faustian bargain which you have now taken on, and I don’t see how you step back from that.”

Challenges

As for challenges, culture and buy-in featured prominently in the discussion. Encouraging companies to share ownership of data across the supply chain and potentially concede elements of competitive advantage will be difficult.

“The culture of digital thread is one of the biggest challenges,” said Chris Greaves. “It’s going to impact on a group of people that it’s never impacted before

/// IF YOU’VE GOT A DIGITAL THREAD, YOU HAVE A LOT MORE UNDERSTANDING OF THE ASSET, HOW IT’S PERFORMING ///



// THIS CULTURE OF DIGITAL THREAD IS ONE OF THE BIGGEST CHALLENGES. IT'S GOING TO IMPACT ON A GROUP OF PEOPLE THAT IT'S NEVER IMPACTED BEFORE //

you're using the data to make valued decisions instead of discussing if the data is wrong," said Neil Young. "And that will take time."

Skills

As ever with any engineering discussion, conversation eventually turned to skills. Merging the physical and the digital comes with a unique set of challenges, pushing engineers outside their comfort zones and demanding new capabilities.

Finding people with the requisite blend of skills isn't easy.

"We want this sort of golden goose of an engineer that understands the mechanical but also the programming side," said Chris Greaves. "It's a real

challenge getting these two worlds to align. It goes right back to

➔ Malcom Lee, Group Head of Technology & Innovation, Babcock International



➔ Brian Holliday, Digital Director, Siemens



and that cultural hurdle is going to be a challenge to solve within your own company, not just in the supply chain and beyond."

Sharing data with multiple parties also raises questions of trust, which feeds back into buy-in. Businesses need to know they can rely on the data that other parties have access to. Distributed ledger technology (DLT), similar to the much hyped blockchain, could help boost confidence in that shared data and its integrity.

"There's a role for DLT to help build trust in something that's inherently untrustworthy," said Brian Holliday.

"I think blockchain, essentially a distributed ledger approach, could be used in conjunction with cloud technologies, giving the level of trust where you're starting to make decisions based on machine data in supply chain."

But as with any new technology, acceptance won't come overnight. "You want to get to the point where

what we're educating people in and where you draw the line between mechanical engineering and computer science. And it is difficult, it's a grey area. And I'm yet to find a golden goose."

An alternative to chasing mythical engineers with the perfect blend of skills is to make sure you have the requisite balance of talent across a team. "I think if you have a team with the right composition and you're able to lead the team in the right way, then you can bring in the right inputs from the different experts around the table," said Malcolm Lee. "Going after the golden goose is always a noble quest, but it's a rare instance that you get there."

According to our panel, one of the reasons these multifaceted, cyber-physical engineers are nigh on impossible to find, is because the courses to produce them simply don't exist.

With digital becoming embedded in virtually all aspects of engineering, there is a need to rethink how the education system deals with the corresponding new skills demands.

"We still don't see courses that reflect the sorts of electro-mechanical and data science skills that we want in engineers for the future," said Brian Holliday. "My own undergrad degree at Cardiff was computer science and electrical engineering and that was as far as it went at the time. I'd loved to have had a dose of mechanical in there as well, but it was the only degree I could find and I haven't seen that landscape improve."

There was agreement that university education needs to evolve, but also that businesses need to do more to support continuous development. Outlining the merits of digital training to executives would be a good place to start.

"For me, one of the challenges in skills is the leadership in companies," said Graham Wren, "getting the CEOs and boards of companies to understand that the world is going to be a very different place, very quickly. They are the people who can make the difference and send people to get trained. So I think the universities and the leaders in the field need to take a particular interest in starting with them." #ENGINEER

MEET THE PANELLISTS

- ➔ Neil Young - Engineering & Technology Director - Babcock International Group
- ➔ Malcolm Lee - Head of Innovation and Technology - Babcock International Group
- ➔ Prof Graham Wren - Special Advisor to the Principal, Strathclyde University
- ➔ Prof Dave Robertson - Head of College for Science and Engineering, University of Edinburgh
- ➔ Brian Holliday - Digital Director, Siemens
- ➔ Chris Greaves - Head of Group IMG and Factory 2050 at AMRC
- ➔ Dr. John Ahmet Ekoyuncu - Director, Through-life Engineering Services Centre - Cranfield



NEIL YOUNG - BABCOCK

Delivering value through data

Digital technologies are critical to the management of assets from power stations to warships, writes Babcock's engineering & technology director

Digital Thread

So what is a Digital Thread? The Digital Thread is a holistic view of an asset's data throughout its entire lifecycle – similar to a digital fingerprint – or digital DNA. The typical lifecycle of an asset starts in design, then moves to build and onto the operational phase, including maintenance and refits/ life extension, and finally to disposal. To achieve this we need to create a powerful framework of digital technologies encompassing all elements - such as concept, design, manufacturing, operation, post-life, and retirement – and all of the multiple sources of digital data need to come together to allow for a seamless transition of information from one phase of a project to another.

Working on something at this scale, it is essential that we collaborate more effectively with our partners, supply chain and industry. Babcock's role in the Type 31 programme is significant as we are responsible for the design and build of the five frigates, while at

the same time being a key long-term partner supporting Royal Navy warships through-life. So our intent is to create a consistent Digital Thread and ensure its successful transition to the operational phase.

So we have to embrace Digital Technology, and in particular, the role the Digital Thread plays in the lifecycle of an asset and its application, to improve the total lifecycle cost for our clients.

Delivering value through data

During design and build we employ Industry 4.0 practices to help provide a seamless data flow to deliver efficiencies during the construction phase. During the support and maintenance phase we will apply our own range of digital technologies and data analytics to deliver that ongoing value for our customers through our iSupport360 approach..

The advanced analytics that underpin iSupport360 help us simplify complex problems, reduce risk and inform the customer at

every stage of the asset's journey, resulting in a fully immersive support service. The benefit of real-time analysis also means we can optimise maintenance and increase the asset's efficiency and availability. Like the Digital Thread, we have to look at how all our technologies and capabilities can cut across any of the assets we manage – be they ship, submarine, critical infrastructure and our people.

Investment in Digital Skills

To deliver this Digital Thread we know we need to invest in our people and give them the skills to embrace the advances in technology. We recognise we will also need different types of skills to support this technology growth and as a result we are working closely with our university partners such as Strathclyde, Edinburgh and Cranfield to deliver this.

Future skills is fundamental to Babcock, and one of the reasons we brought our academic and industry partners together at this event. We need the right skills, the right people, and the right career paths in place for them – be they data analysts, technicians, graduates, or apprentices.

The work we are doing now will allow us to build on our growing investment in technology across our sites and in all the Sectors in which we operate: Aviation, Land, Nuclear and Marine.

Whatever the engineering or technology challenges, physical or digital, we know as engineers we have the ability to solve them. We're looking forward to it. #ENGINEER

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Digital Technologies are moving at a rapid pace everywhere in the world, and for companies like Babcock, it's vital we keep abreast of those changes

The very nature of our business means our customers are turning to us more often to answer those technology challenges. Over the three years I've worked as a Technology director within Babcock we have looked at how we apply new digital technologies to benefit our clients at all stages of a project lifecycle.

From nuclear power stations to warships, the assets we manage are complex and critical, so collaboration with our customers, supply chain and, increasingly, the work we are doing with our academic partners is key. As well as mature technologies, we need to be aware of emerging ones, so we can apply appropriate solutions that will prolong the life of these assets, which sometimes have a lifecycle of 60 years and beyond.

At Babcock we have an inherent understanding of the physical assets we manage, but is that sufficient? Understanding the digital landscape means we can enhance our expertise and work with new technology areas such as the digital footprint of an asset or its digital twin.

When the Government announced our role in the production of the new Type 31 frigate, we were already actively engaging with our subject matter experts within Babcock, our supply chain, academia and of course our supporting partners to plan how these digital technologies would be deployed.

// WE NEED TO INVEST IN OUR PEOPLE AND UPSKILL THEM TO EMBRACE THE ADVANCES IN TECHNOLOGY //

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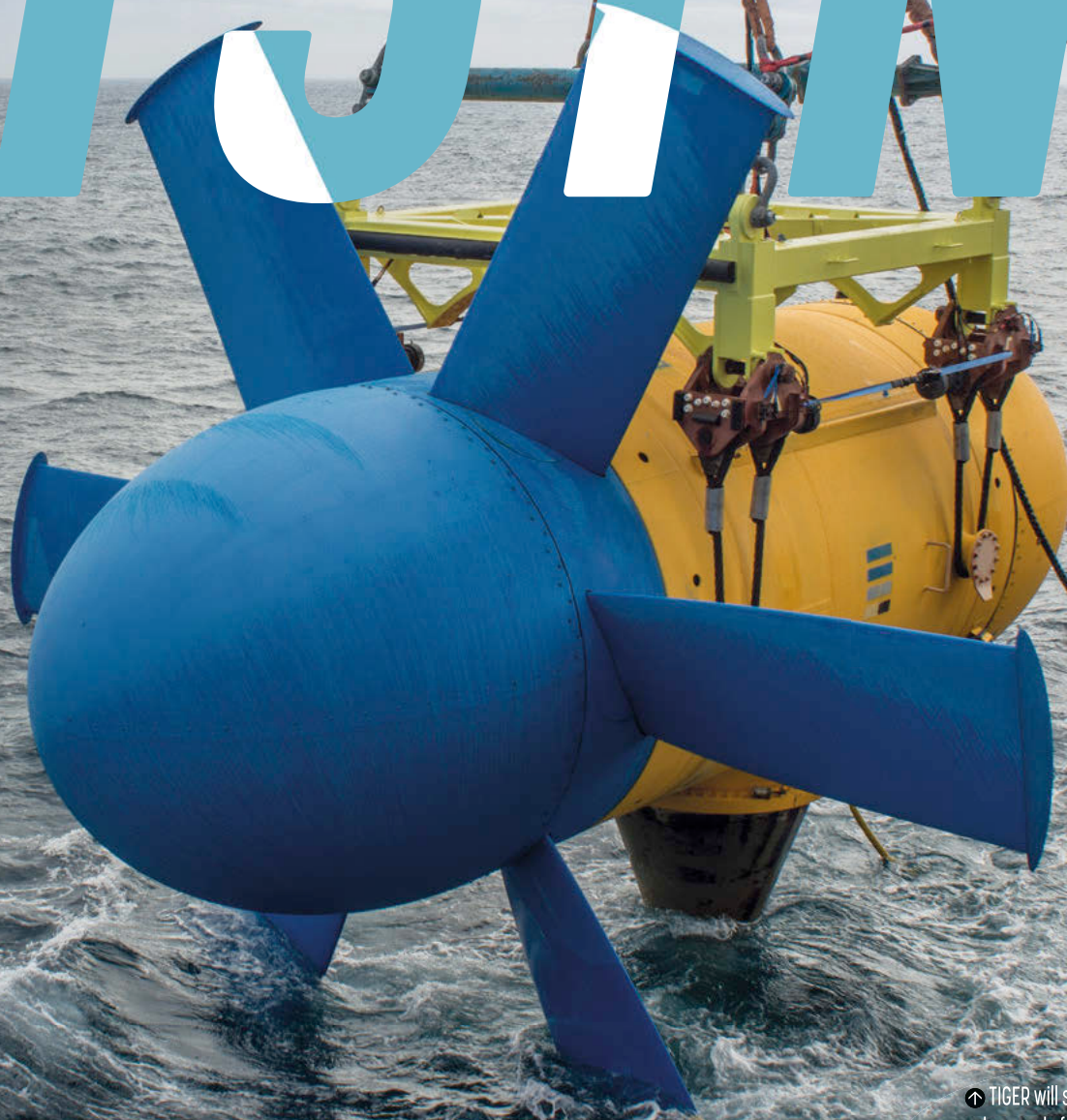
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RISING



↑ TIGER will see turbines submerged offshore to harness the energy of tidal currents. Image: Sabella

GET TIDE

David Fowler reports on TIGER, an ambitious European project that promises to put the UK at the forefront of the tidal energy sector

Renewable energy in the shape of wind and solar power provides an increasing share of the UK's energy mix, reaching 40% in the third quarter of last year. So far, however, tidal power has not made significant inroads into the market.

Over the next three years, the Anglo-French Tidal Stream Industry Energiser Project, or TIGER, is aiming to demonstrate that tidal stream energy is a maturing technology which, with a revenue support mechanism to allow significant deployment, could reduce its costs to a competitive level with nuclear power.

Last autumn the €46.8m (£38.9m) project was awarded €28m (£23.3m) from the European Interreg France (Channel) England programme to install up to 8MW of generating capacity at a number of sites around the south coast of England and the north of France. The award makes it the biggest ever Interreg project.

The programme seeks to gain experience in installation, operation and maintenance of tidal power, demonstrate cooperation with an Anglo-French supply chain, and disseminate the results to help accelerate the commercialisation of tidal stream energy.

Tidal stream energy generates electricity from tidal currents using structures resembling underwater wind turbines, as opposed to tidal range energy projects such as La Rance in France and the proposed [scrapped] Swansea tidal lagoon, which use dams or barrages to impound water and then control its release through turbines.

The TIGER consortium was assembled and is being project managed by the Offshore Renewable Energy Catapult, which



Orbital O2's 2MW floating tidal turbine

has a regional office in Hayle, Cornwall. ORE Catapult sector lead for wave and tidal energy Simon Cheeseman explained that the withdrawal of government subsidies in 2018 left tidal power deployment in limbo. "The UK is at the forefront of wave and tidal technology development, but in the UK there's no revenue support mechanism to enable developers to provide competitively priced electricity," he said. "Tidal power has to compete in Contracts for Difference auctions but it's not competitive because it hasn't got the scale."

Renewable UK has been lobbying for the reinstatement of some sort of revenue subsidy. In 2018, ORE Catapult published a report, Tidal Stream and Wave Energy Cost Reduction and Industrial Benefit, which set out how tidal power could meet three tests for the viability of new forms of renewable energy set out in the government's clean growth strategy. These are that it should have a clear cost reduction pathway; that the UK could develop world-leading technology in a global market; and that it would reduce carbon dioxide emissions. →



The report argued that costs would be driven down by “learning through doing” – gaining genuine experience of installation and operation; and from economies of scale; standardisation of components; working with the supply chain to reduce costs; and innovation offering improved performance. This would provide increased confidence in the technology to bring down the cost of capital and insurance.

The learning through doing aspect is important. Because tidal power equipment has to be installed, operated and maintained in the sea in areas where currents are strong, “the costs, risks and difficulties rise exponentially”, said Cheeseman. Though test rigs can be set up on land, eventually systems need to be tested in the water.

The report also made the point that the investment in the sector would bring an economic boost to coastal communities where traditional industries such as fishing had declined.

“In the report, we were able to demonstrate a clear cost reduction pathway, once we reached 1GW of deployment, to take tidal stream energy to £90/MWh, which would be competitive with nuclear,” he said,

Being competitive with nuclear could be significant. Tidal power is unique among renewables in being predictable. Tides and current flows are published in advance. “As a developer, if you put a turbine in the English Channel, you can calculate with a high degree of accuracy what you will get out of it,” Cheeseman said.

The cost reduction pathway has been widely acknowledged, and TIGER was developed as a way to demonstrate it. In France, the sector faced similar difficulties and there was scope for synergies. In the UK, councils and Local Enterprise Partnerships around the south and east coasts of England as far as Norfolk were interested in investing in the technology. ORE Catapult became involved to pull together a consortium (see box) and continued as project manager.

The UK side is structured around

Consortium partners

TIGER comprises 18 partners from across the UK and France spanning turbine developers, ocean energy demonstration sites, research organisations, as well local and regional authorities.

UK partners:

- Offshore Renewable Energy Catapult (Lead Partner)
- SIMEC Atlantis (in a joint venture with French regional agency AD Normandie)
- Orbital Marine Power
- Minesto AB
- QED Naval
- Cambrian Offshore South West
- Universities of Exeter, Manchester, Plymouth,
- European Marine Energy Centre (EMEC).

French partners:

- Sabella (in a joint venture with French regional development agency Morbihan Energie)
- EDF Hydro
- SEENEON
- Hydroquest
- Bretagne Development Innovation
- Universities of Le Havre, Bretagne South, Caen Normandie.



Group shot of the TIGER project partners

the Marine Energy Council, which brings together all the leading tidal and wave power developers, and as part of TIGER is hoping to create a French equivalent.

The overall objective of the project is to provide evidence that tidal stream energy can take the first steps along the cost reduction curve; to develop a UK/France supply chain, and to work with it to identify critical areas where cost reductions are necessary. These include blade design and manufacture; pitch control systems; subsea cables and connectors; installation methods; and improvements in overall system reliability.

Interreg is keen to see installations at different sites, both tidal channels and headlands, and with different types of turbine. Accordingly, the project will demonstrate floating devices as well as large and small turbines fixed to the seabed, and more novel devices such as that developed by Swedish company Minesto, which resembles a small aircraft or glider with a propeller/

// IF YOU PUT A TURBINE IN THE ENGLISH CHANNEL, YOU CAN CALCULATE WITH A HIGH DEGREE OF ACCURACY WHAT YOU WILL GET OUT OF IT //

turbine. Tethered to the seabed, the glider travels in a figure-of-eight pattern, pushing the turbine through the water at a relative speed faster than the underwater current. This allows it to operate in low tidal flows where a horizontal axis turbine would be inefficient.

Because the Interreg programme is due to end in March 2023, the sites chosen had to be already operational, or close to gaining consent.

In the UK the Ramsey Sound site, off Pembrokeshire in Wales, is being revitalised. It was the site for Tidal Energy Ltd and was a fully-fledged generating site until its Delta Stream turbine developed problems and the

company went into administration. As part of the project, TIGER will be removing the turbine and examining the reasons for its failure.

The site will be operated by Cambrian Offshore South West; a new turbine of potentially up to 1MW will be installed but a decision has yet to be made about its type.

Also in the UK, potential sites in the Solent region are being examined.

In France, Paimpol-Bréhat is an EDF Hydro owned open-sea test site where a turbine was installed and tested last year by Hydroquest. The site will be upgraded to accept a broader range of turbine technology. It is expected that a 100kW Minesto glider will be installed as part of the TIGER project.

At a new site in Morbihan, Brittany, French turbine developer Sabella working with Morbihan Energie will install and operate two 250kW turbines. Sabella regularly installs turbines for testing on the French island of Ushant.

At Raz Blanchard, north of the Channel Islands, Hydroquest aims to complete consenting for a 10MW pilot turbine farm. Normandie Hydrolienne, a joint venture between Edinburgh-based SIMEC Atlantis Energy and the regional development agency AD Normandie, will also aim to complete consenting for their 1.5MW horizontal-axis three-bladed turbine as the first phase of a commercial tidal project of between 5 and 20MW. Atlantis's MeyGen project in Orkney went operational in 2018. Hydroquest will install a vertical blade turbine, allowing comparison of installation, maintenance, power generated and cost of operation.



↑ Minesto's glider technology produces electricity by sweeping a small turbine through areas of low tidal flow

The UK's Orbital Marine Power, which has been testing its turbines at the European Marine Energy Centre in Orkney, will look at tailoring its design and the economics of deployment at the different TIGER sites.

In general, installation of the turbines does not require major construction operations. The seabed-mounted type stand either on steel gravity structures or simple piled foundations, and the driveline and generating equipment are preassembled and contained in a nacelle. An export cable takes power to the shore, where some horizontal drilling under the beach for the cable is required.

Installation challenges arise because the turbines have to be installed where currents are strong, so most work has to be done at slack tide, which lasts only 30-40 minutes. Offshore work will be done by remotely operated subsea vehicles to avoid the use of divers, but they can only

work at low tidal velocities. Further development of installation and support vessels that can operate in shallow waters with high flows is another area to be investigated with the supply chain.

Numerous academic partners in the consortium will be evaluating the data emerging from the project and measuring the performance of the installations. The results will be disseminated by ORE Catapult through a series of workshops, conferences and reports.

In addition to demonstrating the technology's maturity for the UK market, the TIGER project is also hoping to open up export markets, particularly for off-grid island communities which currently depend on diesel generation.

Tidal power has had false dawns in the past, but Cheeseman is confident the project will succeed, not least because of its broad-based nature involving some of the leading developers, engaging with a knowledgeable supply chain and expert marine energy academics from universities in the two countries.

"We've got the cost reduction curve broadly accepted," he said. "We've got the technology. It's all been tested at independently so we know it works. This is about collecting hard evidence to support a cost strategy and putting it into practice." #ENGINEER



↓ Atlantis' 1.5MW horizontal-axis three-bladed turbine





ENGINUITY AWARDS SHORTLIST ANNOUNCED

In its never-ending quest to become ever more productive and competitive, few things are more important to UK engineering than the need to shore up and develop its pipeline of talented engineers.

For this reason, The Engineer is delighted to be a media partner and sponsor for the 2020 Enginuity Skills Awards.

Now in its seventh year, the competition (previously known as the Semta Skills Awards) was established to recognise the brilliant apprentices, champions of skills development, and innovative engineers tackling society's biggest challenges, who will ensure the future of a sector that is the backbone of the UK economy.

This year's awards are the first since employer-led skills body Semta group relaunched as Enginuity as part of a push to help employers get to grips with the skills challenges presented by today's rapidly shifting technological landscape.

The shortlist for this year's awards, outlined over the following pages, provide encouraging evidence of the wealth of exciting engineering talent that will help shape UK industry in the years ahead.

SME Apprentice of the Year

The best apprentices from a business employing under 250 people, who illustrate the opportunities apprenticeships can open and demonstrate excellent engineering or manufacturing skills that have a real impact on their employer's business.

• **Kerrie-Jo O'Flynn**, Space Engineering Technician

The finalists for this year's Enginuity Awards provide a reassuring and inspiring reminder of UK engineering's rich pool of talent and innovation.

Apprentice, Oxford Space Systems

• **Davina Kaur**, Engineering Technician Apprentice, RNA Automation Ltd

• **Jonathan Keating**, Improving Operational Performance Apprentice, MACS Automated Bollards

• **Sadie Kennedy**, Fabrications and Welding Apprentice, Hyde Details Ltd



Large Employer Apprentice of the Year

The best apprentices from a business employing over 250 people, who illustrate the opportunities apprenticeships can open and demonstrate excellent engineering or manufacturing skills that have a real impact on their employer's business.

• **Samuel Garner**, Mechatronics Apprentice, Perkins Engines Company Ltd.

• **Matthew Booth**, Master Craftsperson Apprentice, AMRC Cymru

• **Alexander Moody**, Engineering Manufacture Apprentice, Siemens Mobility Ltd.

• **Raisa Matadar**, Advanced Mechatronic Apprentice, Jaguar Land Rover

Graduate or Degree Apprentice of the Year

The best graduate or degree apprentices, who illustrate the opportunities graduate or degree apprenticeships can open and demonstrate excellent engineering or manufacturing skills that have a real impact on their employer's business.

• **Catherine Llewellyn-Jones**, Engineering Undergraduate Apprentice, Airbus Operations Ltd.

• **Jake Duthie**, Mechanical Engineering Apprentice, Pipeline Induction Heat Ltd.

• **Anesu Chivenga**, Project Management Degree Apprentice, Rolls-Royce PLC



• **Michael Jones**, Through-life System Sustainment Apprentice, Thales UK

Skills Champion of the Year

An individual who has made a significant contribution to the development of engineering and manufacturing skills in the UK.

• **Philip Long**, Apprentice Technical Trainer, Babcock Training Limited, for his continual training developments and use of digital platforms helping to

increase first-time pass rates from 30 per cent to 100 per cent in some apprentice groups

• **Jason Phin**, Training Solutions Business Manager, Siemens PLC, for his passion and commitment to developing engineering skills, within Siemens and beyond, as demonstrated in the delivery of the new Level 4 Automation & Control Engineering Technician standard



• **Anita Davenport-Brooks**, People, Culture and Compliance Manager, Lander Automotive Ltd., for her work future-proofing the business by spearheading vocational qualifications leading to an additional 100 employees (in addition to the 130 apprentices) undertaking vocational qualifications

Skills Collaboration of the Year

Two or more organisations who have collaborated to make a significant contribution to the development of engineering and manufacturing skills in the UK.

• **Jaguar Land Rover** and Supplier Skills Network Group, for its partnership to deliver solutions to the collective skills challenges within the supply base

• **Newport Wafer Fab and Smart Solutions**, for its training programme to develop agency staff to gain permanent employment

• **Langley and Dudley College**,

for developing the first Level 2 trailblazer in multi-disciplined flat roofing.

SME Investment in Skills

A business of under 250 people which has made a significant and innovative investment in engineering and manufacturing skills in the UK.

- **Lindhurst Engineering Ltd**, for demonstrating that all companies, regardless of size, can successfully invest in staff skills training
- **PM Training and Assessing Ltd**, for its Mobile Technical Classroom initiative
- **East Coast College**, Lowestoft for its Energy Skills Centre and 12 week transition into offshore wind programme, helping unemployed local people find a new career path

Training Partner of the Year

A training partner which has made a significant and innovative contribution to developing engineering and manufacturing skills in the UK.

- **University of Sheffield AMRC Training Centre**, for working with over 300 employers to design curriculum with their needs in mind
- **Skillnet Limited**, for its delivery of Automotive Apprenticeships across the UK in partnership with big brands such as Ford, DAF and McLaren
- **JTL**, for helping to creating a better talent pipeline for the industry, especially attracting more NEETs, females and people from Black and Minority Ethnic communities to engineering and manufacturing

Diversity in Engineering

An organisation that has made a significant contribution to diversity in manufacturing and engineering in the UK.

- **Bolton College** for its focus on learning difficulties and special needs programmes
- **STEM Returners**, for its focus on helping ethnic minorities get back

into STEM roles

- **InterEngineering LGBT**, for its work making engineering more inclusive for the LGBT+ community

Skills Innovation of the Year

An innovation that has taken a fresh approach to developing manufacturing and engineering skills in the UK or delivered a real business impact.

- **Signalling Training Mobile Classroom** by PM Training, for bringing a signalling training school to learners in Wales
- **Unipres Training Academy** by Unipres, using state-of-the-art robotic equipment to train young apprentices in a simulated manufacturing environment
- **The Dynamic Demand Planning Tool** by Network Rail Training, leveraging data science to transform the way the rail industry thinks about engineering competences and operational performance

Connected Places Innovation

A UK-based engineer who is making a significant contribution towards the challenge of making society more connected physically, digitally or socially.

- **Professor Harald Haas**, **pureLiFi**, for his LiFi innovation using lighting utility infrastructures to provide more secure, reliable and energy efficient wireless technology



- **Maya Pindeus**, **Humanising Autonomy**, for her work building human-centered tools to define how autonomous vehicles interact with pedestrians
- **James Johnston**, **Piclo**, for its smart and flexible energy system

and technology that helps make electricity grids more efficient, reliable and sustainable

Manufacturing and Materials Innovation

A UK-based engineer who is making a significant contribution towards the future of manufacturing and valuable materials.

- **Lloyd Ash**, **Ashwood Electrical Motors**, for its cutting edge Interior Permanent Magnet technology that reduces the size of induction motors whilst delivering 94 per cent efficiency
- **Benamina Bollag**, **HigherSteaks**, for its cell-based 'meat' product. Sustainable, animal-free foods, indistinguishable in taste from traditional meat.



- **Patrick Dodd**, **Hexigone Inhibitors**, for its chromate-free and 10 times more efficient anti-corrosion technology

The Energy Revolution Innovation

A UK-based engineer who is making a significant contribution towards the UK prospering from the energy revolution.

- **Miles Franklin**, **Graviticity Ltd**, for system designing that has driven forward Graviticity's long-life energy storage technology, enabling the transition to 100 per cent renewable electricity grids
- **Dr Sabrina Malpede**, **ACT Blade Ltd**, for her work in creating the lightest and longest wind turbine blade, which increases wind energy production whilst decreasing the cost of energy
- **Dr Alexander William Faris Reip**, Oxford nanoSystems, for his pioneering nanoFLUX® coating



that dramatically improves the efficiency of heat transfer

The Healthier & Safer World Innovation

A UK-based engineer who is making a significant contribution towards making the world healthier and safer.

- **Kevin Lind**, **Perceptual Robots**, for his Unmanned Aerial Vehicle (UAV), providing inspection engineers with a new, cost effective inspection tool that increases quality, whilst minimising inspection time and health and safety risks
- **Joel Gibbard**, **Open Bionics**, for the world-first medically certified 3D-printed bionic arm and his work in making affordable bionic arms available to young people around the world
- **Laurence Kembal-Cook**, **Pavegen Systems**, for his pioneering flooring technology, that can be used to reward people for making healthier journeys across cities (while generating renewable energy with their footsteps)

Commenting on this year's shortlisted finalists, Dame Judith Hackitt DBE, Chair of Enginuity, says: "Engineers are at the forefront of tackling many of the biggest societal challenges we face today, while at the same time, Industry 4.0 is rapidly changing manufacturing and engineering. It's a challenging and exciting time, and this year's shortlist represents those who are agile and adapting to the evolving landscape, just like we have done with the evolution to Enginuity."

The Enginuity Skills Awards 2020 winners will be announced on 19th March 2020 in London.
#ENGINEER

On-site nitrogen generation for laser cutting

We know that laser cutting is a very competitive industry. If your challenge as a metal fabricator is to reduce your cost per part and maximise throughput whilst keeping the quality of your laser-cut products high, we might have the answer.

If your nitrogen currently comes from bottles or a tank, you can probably reduce your nitrogen costs for laser cutting to one tenth by switching to an Atlas Copco onsite nitrogen generator.

On-site nitrogen supply is not only cheaper, it means you will not have to interrupt production to change bottles or refill your tank. We are sure you'll never want to buy bottled nitrogen again once you have discovered the flexibility, convenience and economy of onsite nitrogen generation.

If you are worried about the impact of making such a big change to your nitrogen supply, we would be happy to show you some examples of similar metal fabrication businesses and laser cutting OEMs who have made the switch and are pleased they

did. We can give advice on purity and flow and will supply the complete nitrogen generation package with warranty and service.

Our range of nitrogen generators are suitable both for intermittent or continuous usage and we have options for high and low flow requirements, as well as high pressure. We supply high purity systems to ensure there will be no oxidised cut edge on your products but, if you are an OEM and require a different specification, we can use our expertise to optimise the system for your requirements.

Atlas Copco is already a big name in air compressors to the metal fabrication industry, and can also supply pipework, vacuum pumps, parts and service to support your laser cutting applications.

Forget transport costs, forget bottle orders and tank refills, and create your own nitrogen on site

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While 'conventional', single material Additive Manufacturing (AM) can no longer be described as an 'emerging' technology, it is definitely still an evolving one. Industries are beginning to rely on additive, and to embrace its functionality and the benefits it can bring. I believe that there is also a greater level of understanding, acceptance and realism about AM's limitations and what it can and cannot do. This acceptance does not translate to complacency, nor does it mean that additive is stagnating or that there is no further room for research or advancement. Quite the opposite, in fact.

Dishing the dirt on AM

Research into AM's development – both single and multi-material – and future applications is essential to ensure it remains relevant. However, we need to keep asking questions, like 'how far has it come?', 'what else needs to be done?' and 'what's just around the corner for AM?'

The Centre for Additive Manufacturing at the University of Nottingham and the MAPP EPSRC Hub of the University of Sheffield, alongside industry expert Phil Reeves, are doing just that. As part of the "pre-conference" day at this year's Additive International summit, they have teamed up to ask these questions, delve into the answers and to address the 'dirty secrets' of AM along the way.

This pre conference day, to be held at the Advanced Manufacturing Building at the University of Nottingham will end by seeking the views of established experts and new AM innovators – both from the presenters and the audience – engaging in some realistic predictions of where



PROFESSOR RICHARD HAGUE

Additive Manufacturing: a mature technology?

Additive International's chair, Professor Richard Hague addresses the shift from conventional AM as an 'emerging' technology to a more established one – and the importance of research in avoiding its stagnation and advancing the potential of next generation, multi-material AM.

Additive Manufacturing is going.

Emerging themes at the main conference

Never afraid to shy away from challenges, we will continue to have honest and frank discussions in the two days following at the main conference, "Additive International" – which this year moves to the exciting new venue of Trent Bridge Cricket Ground. The full summit will feature invited expert speakers from across

leading academic and research institutions, consumer brands, corporates and industry all cutting through the hype of additive and sharing their successes and, importantly, failures.

As we confirm our speakers for this year's summit, we're already seeing some interesting themes developing that reflect where AM applications are headed, including: sustainability, industrial developments, and bio-medical / regenerative medicine

applications, new processes and materials.

"Sustainability" continues to be a double-edged sword for AM. Some view additive as a panacea for industrial sustainability, whereas conflicting evidence also says that AM may well be a less environmentally friendly manufacturing approach. Clearly, there is a spectrum of the issue that is very process, application and material dependent and this debate is an area that we'd like to address at this year's summit.

Equally – and at the other end of the spectrum – we will be exploring the truth about bio-printing and where is this exciting research area taking us.

Highlighting the breadth of the conference – where the aim is to show the audience the very latest in AM across a spectrum of sectors and the incredible versatility of taking an AM approach – we will also be exploring the very latest advances in the consumer and aerospace sectors. So, if you want to keep fully abreast of where AM really is now and where it's going, then I look forward to seeing you in July!

Also, be sure to key an eye out in *The Engineer* for views and insights into AM from this year's Additive International speakers. You can also register for The Engineer Expo, which will be held at the NEC in June, to hear my presentation on Next Generation AM. #ENGINEER



© *Additive International takes place 15 – 16 July at Trent Bridge Cricket Ground. The pre-summit day is on 14 July and will be held at the Centre for Additive Manufacturing within the Advanced Manufacturing Building at the University of Nottingham. Registration opens in March, visit www.additiveinternational.com for more details.*

MACH 2020 PREVIEW

Andrew Allcock looks ahead to this April's manufacturing technology showcase



It is easy for commentators to get dazzled by the latest technological advances and start striding off down that road to the future, which does, of course, always hold more promise than the present.

But new technological advances always take time to permeate through industry at large. At the end of the 1980s, for example, after more than 30 years' development and application of numerical control (NC) and then computer numerical control (CNC), a survey of the day stated that of the UK's 750,000 machine tools, just 8% were CNC. So it is today with Industry 4.0 and artificial intelligence; certainly available and much talked about, but less practiced and applied in wider industry.

Visitors to MACH shows, as their organiser the Manufacturing Technologies Association (MTA) reveals, come mostly looking for new products – 64% of them. And since most of the products are hardware,

it is, visually at least, a hardware show in the main. As James Fudge, head of events and members' services, said at a MACH 2020 launch press conference: "MACH still retains its USP as being one of the only shows that people turn up to with equipment, switch it on and show it running, demonstrating." That said, he added that there are more digital solutions at this year's event. There is no Industry 4.0 area itself, he advised, because the technology will be present throughout the exhibition, alongside or part of

many of those central hardware exhibits.

And that is rather the point with Industry 4.0 in the engineering manufacturing sector. Manufacturing technology developers are enhancing their hardware. This sees equipment connected, data extracted and variously processed locally or in the cloud to make it run more

effectively and drive up quality. Industry 4.0 is also the umbrella under which artificial intelligence (AI) is being added to production technology. Furthermore, digital representations (twins) of the working envelope deliver safer programs and manufacturing cycles.

There is a Digital Solutions for Manufacturing zone, typically software providers taking in CAD/CAM and production control, and these will similarly have



enhanced their offerings with, for example, AI. Siemens is resident in that zone and will probably have the broadest digital message.

Details of both physical and digital technologies on show at MACH have not yet started to arrive in Machinery's office, but since MACH 2020 follows Europe's EMO show held last year, a rereading of the EMO review (<https://is.gd/ahunez>) might prove illuminating. Our next few issues, and our website, will put more flesh on MACH 2020's bones, of course.

But what about the show, its location and various elements? Already before the New Year, 95% of available space had been sold, the MTA reported at the end of November. This year represents the second MACH in the new location. Still at Birmingham's NEC, it is now housed in several connected halls, all on one level (Halls 6, 7, 17, 18, 19 and 20), having moved in 2018 from its long-time home of Halls 4 and 5.

Signposting was an issue at the first outing in the new location, so the MTA has created wayfinding logos to help visitors better understand their location, as regards zones, of which there are 10: 3D Printing & Additive Manufacturing (AM); Automation for Manufacturing; Digital Solutions for Manufacturing; Grinding and Abrasives; Lasers for Manufacturing; Logistics for Manufacturing; Measurement and Inspection; Surface Finishing; UK Supply Chain; and Welding.

Another zone, but this time not a technology area, is the Education & Development (E&D) zone (Hall 17). Again this year sponsored by Sandvik Coromant, some 15% of the 25,000+ visitors to MACH are students. Within this area, where stands will be identified by a logo too, will be the Sheffield University's



Five things to do at MACH 2020

- James Selka CEO, MTA

With over 500 exhibitors occupying over 26,000 square meters of exhibition space at the NEC, knowing where to start at MACH 2020 can seem a little daunting. So, I am going to help to navigate your way around the UK's national manufacturing and engineering show, with my top five tips of what to do at the exhibition.

1

SEE THE LATEST TECHNOLOGY

MACH 2020 is the place to find out about all the technology that can make your business more productive. The show is broken down into individual zones, which focus on specific types of manufacturing technologies.

If you're looking to find out about automation or additive manufacturing, in need of a new CNC machine or metrology equipment, MACH 2020 has you covered. The zones are easy to navigate, and we have worked hard to ensure the best exhibitors are in attendance.

2

LIVE WORKING MACHINERY

MACH 2020 is the only exhibition of its kind in the UK. One of the main distinctions between MACH and other engineering shows is the volume of live working equipment. If you are looking to make a purchase, you'll be able to see equipment under power and running. This helps visitors better decide if the product suits their manufacturing needs.

MACH happens every two years for this reason, the sheer amount of equipment that is bought to the NEC. Exhibitors want to launch new product and show off the capabilities of their equipment to visitors.

3

SEMINAR PROGRAMME

The seminar programme at MACH is always one of the biggest highlights of the show, we source the best speakers from industry to help inspire our visitors and get them thinking of to improve their businesses.

We already have confirmation of speakers from BAE Systems, as well as Jürgen Maier providing an update on Made Smarter and how this will impact on UK industry. Plus, many more speakers being announced in the coming weeks.

4

EDUCATION AND DEVELOPMENT

We put a lot of work into portraying the best side of our industry. Careers in engineering are rewarding with real chance for progression and growth. The plan for MACH 2020 Education and Development Zone is to have more contextual, technical demonstrations. For example, we have Airbus Defence and Space attending, who have offered a component from the ExoMars Rover as a demonstration workpiece for the Technical Showcase.

Over the past two exhibitions we have had close to 6,000 students tour the show and we aim to inspire many more in 2020.

5

TAKE MORE THAN ONE DAY

I can't stress this enough. The simple fact is that there is so much to see, so many opportunities to network and so many chances to learn from other organisations that it is difficult to fit it into one day.

You see, it is as much about the knowledge being transferred and having some of the industries brightest minds all in one place, as it is the equipment on show and the wonderful exhibitors. So why not take advantage of this opportunity and experience everything MACH 2020 has to offer.

So, what are you waiting for? Make sure you don't miss out on MACH 2020. Visitor Registration is now open at www.machexhibition.com register today and beat the queues. Make sure your company are properly getting the benefits of the UK's national manufacturing show - we look forward to hosting you at the MACH 2020.

James Selka, DL, Manufacturing Technologies Association, CEO



Advanced Manufacturing Research Centre's MANTRA (Manufacturing Technology Transporter). This is a specially customised 14 m HGV trailer packed with the latest machinery and simulators, designed to give aspiring young engineers a hands-on experience with real cutting-edge technologies. Airbus Defence and Space's Mars rover vehicle Bruno will also be a feature of the E&D zone. Bruno will support the 2020 ExoMars mission, a European Space Agency programme executed in cooperation with Russian Space Agency Roscosmos, with contribution from NASA. The six-wheeled rover will carry technology developed by other parties and so will be able to drill down to two metres to take rock samples that will have been protected from harsh solar radiation. The samples will be analysed on board the rover and the results sent to Earth.

The E&D zone will see Vex Robotics give students the opportunity to have a hands-on robotics experience. The company has also developed teaching resources to support its

educational robots' use. And on that point, the zone will have more for teachers this year, highlighting continuing professional development (CPD) opportunities related to manufacturing.

The exhibition includes an even larger number of trade associations, along with their members. This year's MACH will see 10 associations represented: Aluminium Federation (ALUFED); Association of Industrial Laser Users (AILU); British Abrasives Federation (BAF); Cast Metals Federation (CMF); Confederation of British Metalforming (CBM), GTMA, Metalforming Machinery Makers' Association (MMMA) and Processing and Packaging Machinery Association (PPMA), which also takes in the British Automation & Robot Association (BARA) and the UK Industrial Vision Association (UKIVA); and, finally, UK Lubricants Association (UKLA). Some of these have their own areas, such as GTMA's pavilion and MMMA's 650 m² village.

For MACH 2020, organiser the MTA has also brought in some of the UK's High Value Manufacturing (HVM)

Catapult centres – Sheffield University's Advanced Manufacturing Research Centre (AMRC), the Manufacturing Technology Centre (MTC) and Strathclyde University's Advanced Forming Research Centre (AFRC). "It's the first year that we have had that many Catapult centres in the room," Fudge emphasised. The AMRC last time put on a show that highlighted how sensors could be retrofitted to existing equipment – "one of the busiest stands at the show" – and this year's MACH will build on that. The MTC will be highlighting its DRAMA project

(Digital Reconfigurable Additive Manufacturing facilities for Aerospace), a £15 million MTC-led project that encourages suppliers to the UK aerospace industry to adopt AM. Supported by £11 million from BEIS's Industrial Strategy Challenge Fund, DRAMA has already engaged with more than 50 aerospace supply chain companies and is still inviting applications for new projects. In addition to the individual HVM Catapults, the HVM Catapult itself is taking a stand this year, with a focus on SME engagement and adoption of new technology.

In addition to that, 'Made Smarter' and HS2 will both be at the show. HS2's presence is very much about engaging with the UK supply chain – in the UK Supply Chain zone in Hall 6. 'Made Smarter' helps makers keep their competitive edge, with digital tools. Made Smarter, also in Hall 6, offers fully funded advice from specialist technology experts to member companies. It helps companies identify the right digital tools and how to use them





to make everyday improvements to their businesses. Both will be part of the yet-to-be-detailed seminar programme.

Finally, the show is supported by Lloyds Bank for the 10th year as headline sponsor. Relationship director, London & South Mid-Markets at Lloyds Bank Commercial Banking Rebecca Wicks gave an overview of the organisation's engagement with the manufacturing sector. "Since 2014, Lloyd's has committed nearly £6 billion of new lending to the manufacturing sector. And for the three years 2018 to 2020, we pledged a further £3 billion. My team is doubling in size in the next few months [serving companies with £25-100 million turnover], so we see the sector as a huge growth opportunity for us to help support and pull the UK economy as a whole. We support around one in five manufacturing businesses throughout the UK and across all sectors. Our commitment is for the long term, helping Britain prosper."

She underlined that the current £1 million Annual Investment Allowance, increased from £200,000 in January 2019 until the end of this year, has seen less take up than anticipated.

It seems that many SMEs are unaware of this change, she added, but stated that visitors to MACH 2020 have a further nine months to take advantage of this generous investment support.

Turning to the issue of skills, she told the audience that Lloyds is also providing support here. "Knowledge is the future, so we also want to help fight the skill shortage within the sector, to protect and enhance the long-term future of manufacturing in the UK. We've pledged £10 million of sponsorship to the MTC to train apprentices, graduates and engineers over 10 years through to 2024.

"So far this has enabled the training and upskilling of almost 200 apprentices, 300 engineers and 80 graduates. We're immensely proud of our sponsorship and the support it provides for those that will be the future of the manufacturing sector."

Indeed, MACH this year is, as ever, focused on the future, providing the shop window to the technology that will make the coming decade's promise reality.

This article originally appeared in sister publication Machinery ENGINEER

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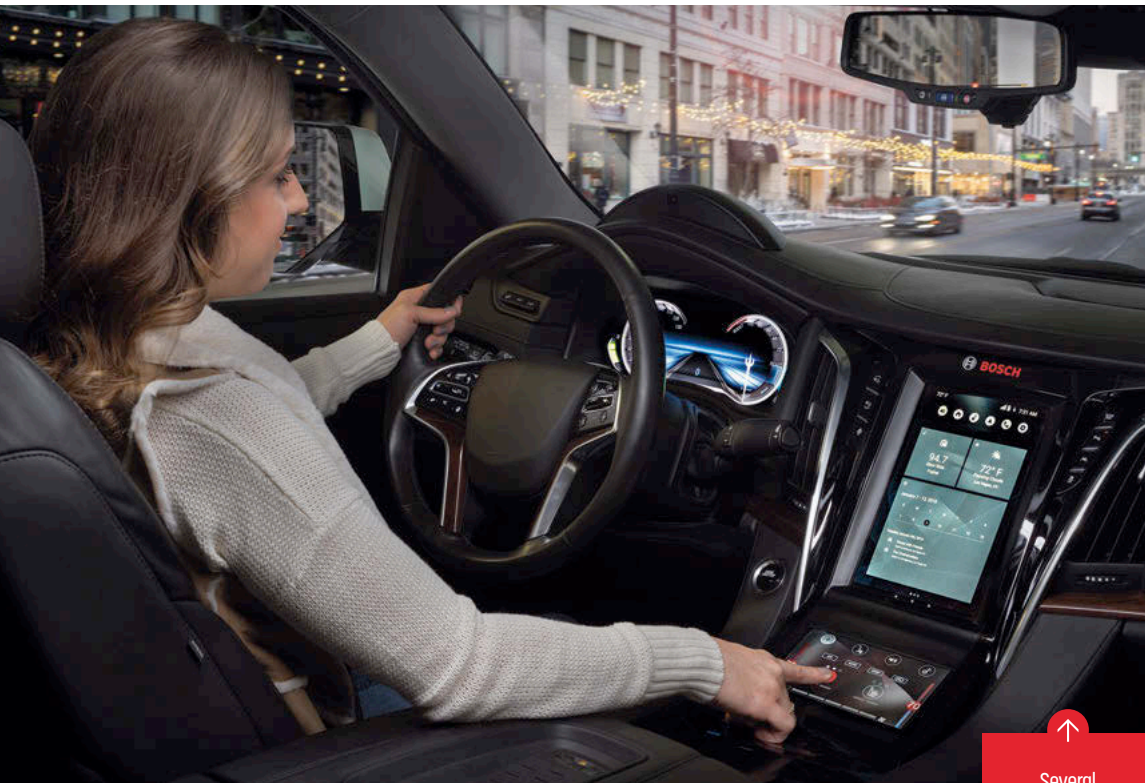
The MTA is encouraging people to start now, Tweeting, using Facebook and Instagram, talking about the show, letting others know they are going. So, as part of the registration process (live now www.machexhibition.com), at the end of it people are asked if they want to connect to their social media profiles.

Similarly, on the MACH website itself, there's a new 'engage' module. So, if there are specific exhibitors that visitors want to see, they can set up meetings with them before the event. The same badge technologies as were used in 2018 will be employed, with contact details read from these. You can link with the MTA via:

 www.facebook.com/MTAEandD,

 www.linkedin.com/company/the-manufacturing-technologies-association

 twitter.com/mta_uk.



The Cockpit of the Future

Is it really possible to keep adding cockpit functionality without distracting the driver? Chris Pickering looks at some of the technology designed to offer the best of both worlds

CHRIS PICKERING REPORTS

Cars are getting cleverer. Even the lowliest hatchback can now be had with features that most drivers could only dream of a decade ago. The challenge with all these extra functions is how to provide a safe and intuitive interface at the same time as delivering the glossy high-tech experience that buyers increasingly crave.

As the executive cars of the nineties proved, there comes a point where

adding more buttons and switches becomes impractical. Touchscreens are a logical progression in an era when almost everyone uses a smartphone, plus they allow users to scroll through multiple menus on a single interface.

Touchscreens aren't without their drawbacks, however, and chief among these is how to minimise distraction when drivers may have to glance down at the screen. Fortunately, the automotive industry is rapidly coming up with

solutions – some extremely sophisticated and others ingeniously simple.

Contoured displays

The main reason that traditional buttons and switches fall so easily to hand is that you can locate them purely by touch. A number of tier one suppliers are currently working on shaped touchscreens with features such as ridges and dimples to replicate this ability. The key benefit is that digital screens can still handle multiple functions, unlike conventional buttons, and the touchpoints can be integrated seamlessly into the display.

Finnish technology company Canatu has been working with Faurecia on stretchable and 3D formable touchscreens for automotive applications. These use Canatu's proprietary Carbon NanoBud (CNB) material, which is a hybrid of single-wall carbon nanotubes and fullerenes, designed to combine high electrical conductivity, favourable optical qualities and impressive formability. Examples include a domed touch pad, which provides 360-degree sensing.

Several manufacturers, including Bosch, are exploring the use of haptic displays to provide tactile feedback to drivers

Haptic feedback

Haptic displays take the sensation of touch one step further by mounting the screen on an actuator. By modulating the force feedback as the user moves their finger over the screen it's possible to create the sensation of bumps, rids and textures on a completely smooth display.

Continental was one of the pioneers of this concept with its Haptic Feedback Display, mounted on a series of electromagnetic actuators. Bosch soon followed with its NeoSense interface. This monitors the pressure applied to the screen, so the user can gently swipe over the virtual buttons or press harder to activate them. Varying the pressure also allows the user to control other functions, such as the speed at which the system scrolls through its menus.

// THE CAR INDUSTRY IS RAPIDLY FINDING SOLUTIONS TO DRIVER DISTRACTION //



3D images

Aesthetically pleasing displays are a major selling point in modern cars, but clever visual representation can also help to improve driver information and reduce distraction. There's growing interest in the use of 3D graphics, which can quite literally bring important information to the foreground, while retaining less critical information behind.

A variety of different approaches have been showcased for this functionality. Aptiv's MLD technology uses two LCD displays separated by a gap of 6 mm. This creates a seamless perception of depth without the need for special glasses or headtracking cameras.

Visteon has applied a similar principle with its 3D Blade concept, which is used for the instrument cluster on the new Peugeot 208. It features a high-definition 10.25-inch 'background' TFT display and a 7-inch 'foreground' TFT display that's projected onto a semi-reflective blade. The leading-edge display creates a 3D projection of approximately 15 mm between the front and rear images.

On test: Hyundai's Cockpit of The Future

Hyundai's Cockpit of The Future combines all of these concepts into a working prototype based around an i30 hatchback. It began with a project that aimed to clean up the human machine interface (HMI) around the steering wheel.

"Currently we tend to see around 10 to 20 buttons on the steering wheel depending on the manufacturer," explains Regina Kaiser, senior HMI engineer at Hyundai Motor Europe Technical Center. "In psychology, people talk about the Magic Number – seven plus or minus two – which is the number of tasks that people can typically hold in their short-term memory. We wanted to reduce the number of buttons on the steering wheel down to that level so they could operate them with muscle memory alone."

Rather than use physical buttons, the Hyundai engineers fitted two miniature haptic display panels – one within reach of each thumb when your hands are placed on the wheel. Most of the

// NONE OF THIS TECHNOLOGY IS FAR FROM PRODUCTION //

time, these are each divided into four quadrants, with the main infotainment controls on the left and a set of arrows for navigating more complex functions on the right. Go into the settings menu and you can change the functions controlled by each of the virtual buttons, as well as their position on the pads.

Aesthetically, this gives the steering wheel a distinctive appearance, while the familiar location of the pads, combined with their haptic feedback, means that they're very intuitive to use. The integrated display helps you keep



↑ Innovative cockpit technologies include centre consoles that use 3D imaging, and domed touch pads that provide 360-degree sensing. Images: Canatu

track of which function is assigned to each virtual button, plus the car can automatically reconfigure the touch pads to suit different modes or situations.

A great example of this flexibility comes when the system receives an incoming telephone call: nine smaller buttons (or up to 20 on a conventional steering wheel) are suddenly replaced by just the two that you actually need – one to accept the call and the other to reject it. This ability to pre-empt your inputs is where the system really scores above a normal set of passive buttons.

Hyundai's haptic interface works in



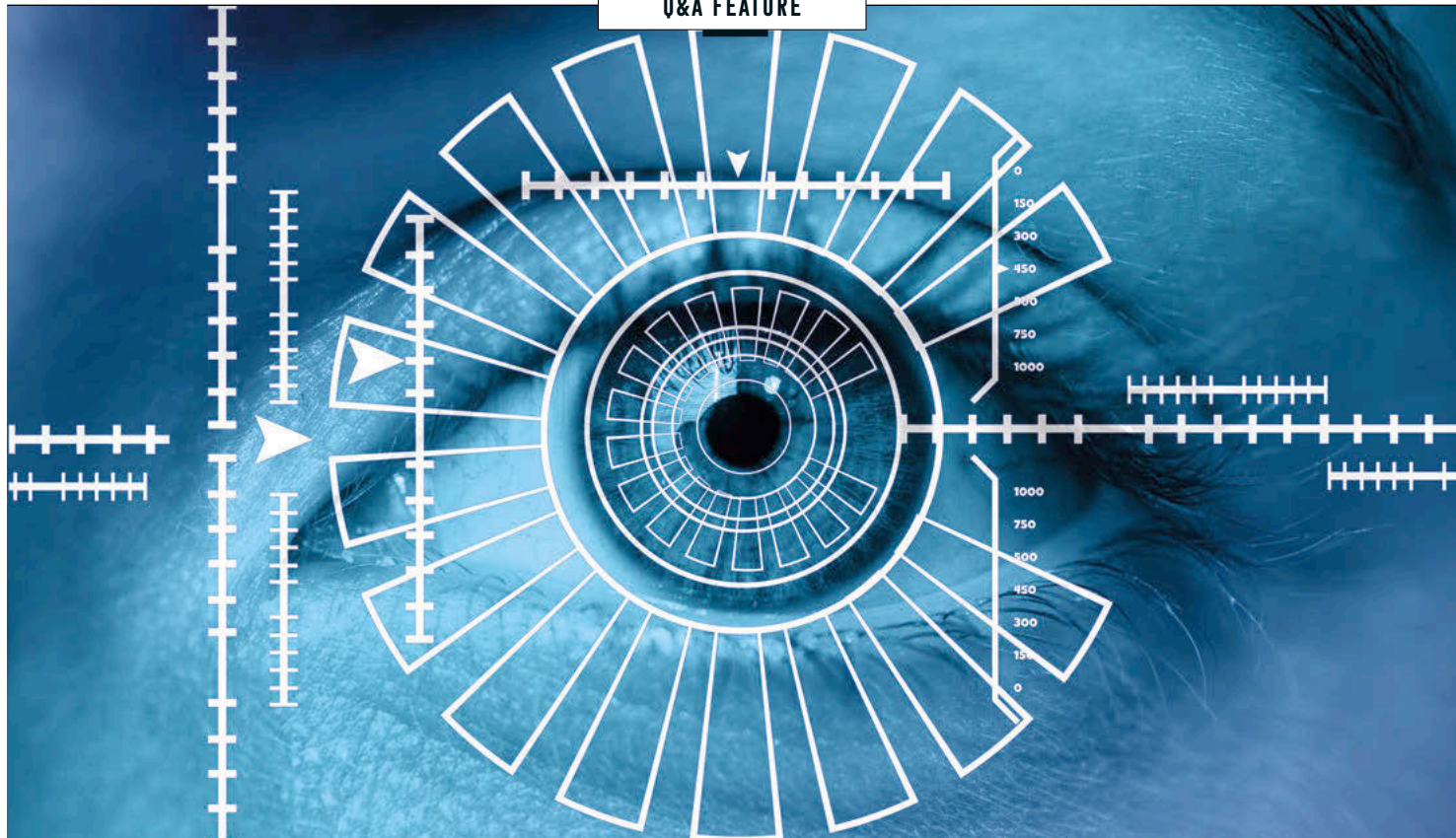
conjunction with a 3D instrument cluster supplied by Aptiv. The effect is extremely convincing; in its default setting there's a raised ring around the speedo that you'd swear was a plastic moulding, right up until the point that you change modes and the pixels glide seamlessly away. The ability to stack information at different depths really does help to prioritise certain elements – particularly when new information moves to the front. Overall, it's no more distracting than glancing at a traditional analogue speedometer.

Crucially, the 3D cluster feels completely natural to look at. It works across a wide range of viewing angles without any ghosting or blurring. In the brief time we sampled it there was no evidence of eye strain or disorientation either – both of which can be issues with things like 3D televisions.

The final trick up Hyundai's sleeve was a large haptic touchscreen in the centre of the dashboard. This is based on an off-the-shelf display mounted on Hyundai's own piezo electric actuators. There's a perceptible degree of movement before the actuators can kick back – that's something that Hyundai is looking to reduce – but the haptic sensation is brilliantly vivid. You really can feel the boundaries and textures as if they were there. The subtle click generated by the piezo actuators is also quite pleasant and acts as an additional audible cue. It all adds up to a pleasingly tactile experience that heightens the sense of interaction with the car and reduces the need to look at the screen.

None of this technology is far from production. It demonstrates how these increasingly sophisticated HMI systems can actually be used to simplify the

way that we interact with our cars instead of complicating it yet further. Common sense will be needed on behalf of both the drivers and the engineers to ensure that additional functionality doesn't lead to greater distraction, but there's proof here that it doesn't have to be the case. #ENGINEER



B iometric authentication, where physical characteristics like fingerprints or iris recognition are used to establish identity, is a rapidly growing area of development. The Engineer caught up with some leading voices in the sector to find out the latest trends, as well as gauging how the technology stacks up against traditional authentication methods.

Meet the experts

Mohammed Murad, vice president, global sales and business development, Iris ID
Dr Sarah Morris, senior lecturer in digital forensics at Cranfield University
Tugberk Duman, biometrics expert and head of innovation at Futurice

What is currently the most exciting technology trend in your area of biometrics?

SM: In digital forensics, one of the big things we are always asked is “who was at the keyboard?” This has often been a question we have not been able to answer as we can say what the digital device was doing, and what user interaction occurred, but often had no definitive way of linking that to a person. Biometrics such as facial recognition and fingerprint locks are therefore very exciting to us. They enable us to start

Q&A:

Biometrics

An expert panel discusses how technologies such as iris and facial recognition are ushering in the post-password era

ANDREW WADE REPORTS

to identify who was likely at the keyboard as their biometric data allowed access to the device, and therefore give us more information in an investigation.

MM: Probably the biggest game changer is the ability of iris recognition systems to serve as an end to end security solution for almost any organisation. This, in effect, may provide one solution for both physical and logical security needs.

As an example, if an employee arrives at work, she looks into an iris reader. If there’s a match the access control system is instructed to open the door. Once inside, an iris reader integrates with the elevator operating system making sure she gets to her restricted floor. Finally, another reader integrated

with software on her workstation ensures only she may access the computer and its data. This is a good step toward bringing physical and logical security into one silo, as opposed to the separate silos we continue to see.

TD: I don’t think any particular technology alone is particularly exciting. What excites me are the new experiences technology can unlock. So with that, I focus on biometrics technologies that imitate human intuition, facial recognition, behavioural biometrics and voice recognition. These technologies identify the users similar to how we humans do it, by how we look, by how we behave, and by how we sound. They have the immense potential to make our interaction with technology much more natural and intuitive.

How will biometrics integrate with existing technology and what are the key challenges around this?

MM: Biometrics integrate well with many existing technologies. Virtually all major access control solution providers integrate seamlessly with leading biometric technologies. This enables an organisation to migrate toward a biometric solution as time and budgets permit.

Our systems are based on open standards. So, it’s simply a matter of

// THE KEY CHALLENGE IS AROUND ENSURING THE PRIVACY AND SECURITY OF BIOMETRIC DATA // Sarah Morris - Cranfield



// BIOMETRICS TECHNOLOGIES WILL COMPLETELY REVOLUTIONISE PROCESSES BEYOND RECOGNITION IN THE LONG RUN //

Tugberk Duman

working closely with the developers of other solutions to ensure the systems are well integrated.

TD: Biometrics technologies are coming to our lives in two ways. They are first integrating into the existing infrastructure as a new shiny layer to the same process of authentication. Replacing passwords is a good example.

Second, they will completely revolutionise and alter certain processes beyond recognition in the long run. We are seeing signals of this already. The retail industry is being populated with new shopping experiences like Amazon Go and Smart Vending Machines, the aviation industry is talking advanced passenger processing, where people with valid tickets won't be stopped anywhere thanks to the invisible authentication process with facial recognition.

SM: I think standardisation of integration is likely to be a long way off. Due to this, integration is likely to be varied for some time depending on how core the biometrics are to the intended functionality of the device. The key challenge is around ensuring the privacy and security of the biometric data to ensure that individual users have knowledge their personal data is safe and being used in a manner they agree to.

How secure is biometric technology compared to current security solutions?

TD: First of all, biometric systems, are much more accurate in identifying individuals than the human-operated systems that we have in airports for example. When using biometrics, there are three main aspects to consider: cost, security, and convenience. More high-risk, security-sensitive applications can use iris recognition, whereas a retail application aiming for convenience would go with face recognition.

SM: Like everything in technology the answer is 'it depends'. Security doesn't just come from the technology, but the combination of the hardware, operating system, software and updates on the device. Of course, users and environment can also impact on security. Therefore it's not about how secure this one type of technology is but its potential to add additional security in the context of a larger system.

MM: Security is one of the strongest selling points of biometric technology. Let's look at a traditional access control system. An employee's access card can be borrowed, lost or stolen. There's no guarantee that the person using a card has been authorised to use it. There's no doubt about an employee's identity when authorisation is based on a physical characteristic unique to each person.

Biometrics are also highly resistant to cyberattacks. For example, when a person is enrolled in an iris-based biometric system, algorithms convert the iris patterns into small encrypted digital templates that cannot be re-engineered or reconstituted to produce any sort of a visual image capable of



Mohammed Murad
- Iris ID



Dr Sarah Morris
- Cranfield University



Tugberk Duman
- Futurice



TECH DETAILS
Iris ID's iris recognition system is one of a number of increasingly widely deployed biometric technologies

spoofing a system reader. There is no way a hacker can successfully steal these images.

When will we see biometric solutions adopted en masse and become part of everyday life?

MM: Biometric solutions are already a part of our everyday lives. Our smartphones use an iris, fingerprint or facial pattern to unlock the device. Many banks' ATMs include biometric readers to identify a person without the need for a card or PIN. Medical facilities are using biometric systems to identify patients prior to beginning treatments or prescribing drugs. Law enforcement and border officials take portable biometric devices into the field to enrol and identify potential suspects. Many employers use biometrics as part of an overall time and attendance solution.

SM: Phones already have options to take advantage of facial and fingerprint-based locking. I think at the moment there is still too much uncertainty and concern about how the data is stored, who will have access and how it will be used for it to become part of everyday life. However, like all technology it often only takes one device or platform for the shift in what users are comfortable with or want to change!

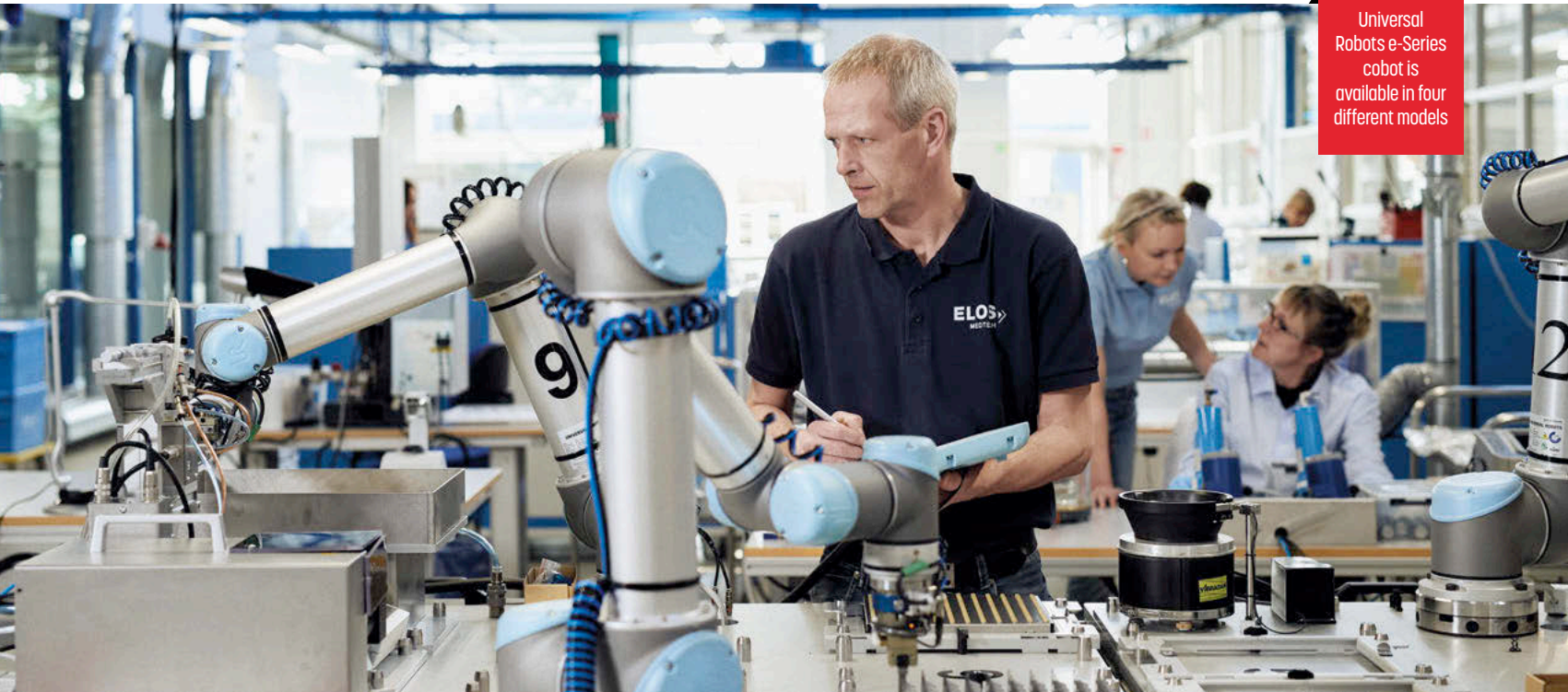
// BIOMETRIC TECHNOLOGIES ARE ALSO HIGHLY RESISTANT TO CYBERATTACKS //

Mohammed Murad

TD: Biometrics have been around for a very long time, but the cost and limited availability have made them exclusive to law enforcement and forensic use cases. However, as these technologies become more affordable and available, we're already starting to see applications in the mass market for consumer use. Airports, cars, our smartphones, our homes even with the smart assistants are full of biometrics enabled solutions already. #ENGINEER



Universal Robots e-Series cobot is available in four different models



Q&A:

HELPING HANDS

Experts from ABB, Festo, Fanuc and Universal Robots offer their perspectives on the fast-moving field of cobotics

THE ENGINEER REPORTS

Collaborative robots are becoming an increasingly key technology for manufacturers, enabling them to cost-effectively embrace the benefits of automation and exploit the advantages of a closer working relationship between humans and robots. The Engineer asked a panel of experts for their views on the current state of the art in this rapidly growing field.

Meet the experts:

Mark Gray - UK Sales Manager, Universal Robots

Nigel Platt - LBL Manager UK and Ireland, ABB

Steve Sands - Festo GB head of product management

Oliver Selby - Technical Sales Support Engineer at FANUC UK

What are key trends in cobots at the moment?

SS: The fast growth in interest and sales of cobots is in many cases due to their ease of use. Outside of academia, most applications we see are not truly collaborative but are co-existent, with a shared or overlapping work space for human operators and robots. The control features, performance limitations, design and surface treatments enable these robots to be safely installed within this shared space and this is driving the fast uptake and acceptance. Falling prices are a key commercial trend: as volumes increase, there is more pressure to drive down costs, and this is reflected in average prices.

Technical developments are very much around topics such as vision and sensor systems integration. This means making it easier to bridge the gap between the very simple programming that cobots have brought us – teach-in positions, drag and drop, icon-based instructions, etc. – and the add-on functions such as inputs from vision systems for component selection and orientation. Essentially, it's all about adding flexibility and utility to these devices, increasing the scope of their capability.

Cobots are an integral part of the overall digitalisation / Industry 4.0 evolution. Their increasing use of open

standards enables them to connect and communicate within the umbrella environment, taking and sharing data.

MG: Customer demand for flexible automation is driving huge advancements in the market for “plug and produce” end-of-arm tools. Universal Robots' cobots were always intended from day one to make automation accessible to companies of all sizes but the huge range of “off the shelf” grippers and other accessories that have become available is now

/// COBOTS ARE AN INTEGRAL PART OF THE INDUSTRY 4.0 EVOLUTION ///

Steve Sands, Festo GB



// OUR CR-35IA IS USED TO INSTALL LARGE COMPONENTS ON AIRCRAFT //

Oliver Selby, FANUC UK

taking this even further. Our ecosystem of out-of-the-box end-effectors, is continually growing and now numbers over 200.

NP: Simple to install, cobots are also easier to program and operate. Reducing implementation costs, collaborative robots make it possible for SMEs to adopt cobots to replace dull, dangerous or dirty jobs previously done by people. Employees can then be upskilled as robot operators or placed in more creative roles.

What's the key product for you currently and how would you describe its benefits and advantages?

OS: With a view to tackling global skills shortages and the need to increase production flexibility, FANUC has launched its first ever lightweight collaborative robot, the CRX-10iA. Weighing just 39kg, it can be easily installed across a broad range of applications. Crucially, underneath the CRX-10iA's ergonomic frame lies a fully-functioning industrial robot, with



For Festo, cobots are a key tool in the delivery of Industry 4.0

a payload capacity of 10kg and a vision system that enables autonomous loading and unloading of containers or shelving systems.

MG: Our main product is the e-Series cobot which we offer in four different models. An evolution of our original cobots, the e-Series retains our founding principles of creating user-friendly robots that are affordable, flexible and easy to programme and redeploy. However, further developments in the hardware and software have enabled us to offer further advantages to customers with this new line. For example, an in-built force/torque sensor enhances precision and sensitivity. Each joint is easily replaceable and it comes with 17 built-in safety functions for the benefit of its operators.

NP: SafeMove2 is a suite of software which allows operators

greater freedom to collaborate with robots in a limited space. It can be used across the entire range of industrial ABB robots, making every robot a cobot. It uses configurable electronic motion detection and prevention measures which restrict a robot's speed, motion and position when a person comes near.

Another key product is our YuMi cobot, which can work hand-in-hand with humans without further protective measures. It can perform the motions required in small parts assembly within a very small space while maintaining a human-like reach. This minimises the spec needed and makes it possible to install YuMi into the workstations currently used only by humans.

How are your products helping customers meet the challenges that they are facing?

OS: FANUC's diverse portfolio of industrial robots opens a pathway for anyone looking to automate, from small, incremental steps, through to



ABB's Yumi cobots are now used for a wide variety of applications

// IT'S BECOMING MORE DIFFICULT FOR SMES TO RECRUIT SKILLED LABOUR //

Mark Gray, Universal Robotics



significant levels of investment.

A perfect example of this is Cranfield University's Aerospace Integration Research Centre (AIRC), which has turned to FANUC's collaborative robots to boost productivity and cut cost through greater human interaction. The CR-35iA is used to install large components on aircraft, such as wings, which are heavy and awkward to manually move about.

MG: It's becoming more difficult for SME manufacturers to recruit and retain skilled labour so finding sustainable ways to increase the output per worker is proving a regular challenge. For example, there's a very forward-thinking garden furniture manufacturer in Sleaford, Lincolnshire that is using our cobot to sand down wooden parts. The company has increased its output per worker and the staff are happier as the cobots have freed them up from one of the more monotonous and unpleasant aspects of their role. Another common challenge we're helping with is worker safety. For example, Carlsberg has almost eliminated accidents at its Fredericia plant in Denmark since integrating cobots into its operations.



FANUC's portfolio of industrial robots opens a pathway for anyone wanting to automate

NP: Payments software provider Abrantix uses ABB YuMi robots to automate their testing. The Abrantix software instructs the YuMi robot to test common ATM operations such as inserting cards, typing in PIN codes and withdrawing and inserting money. Human errors such as inserting money bound with a paper clip can also be tested. Equally Panda Confectionery in Finland uses YuMi to pack its range of pick and mix confectionery into boxes. The results are a boost in productivity and competitiveness for the Finland based plant.

How do you see cobotics evolving in the coming years?

OS: One area in which cobots are likely to make significant advancements is with their external sensors. Current sensing technology limits the speed at which cobots can work because it cannot assess quickly enough if a person is getting too close. As vision systems catch up, cobots will be able to work more quickly, and increase overall efficiency and productivity, without compromising on safety.

Another exciting possibility is the potential improvements they offer to factory accessibility. Manufacturing facilities are invariably standardised. However, collaborative robots present the opportunity to adapt to the unique requirements of the operator. Taking component assembly as an example, this could be through the cobot holding components in the most ergonomic position, at a height to suit the employee. For anyone with limited mobility, such as those in a wheelchair, this opens up a host of possibilities.

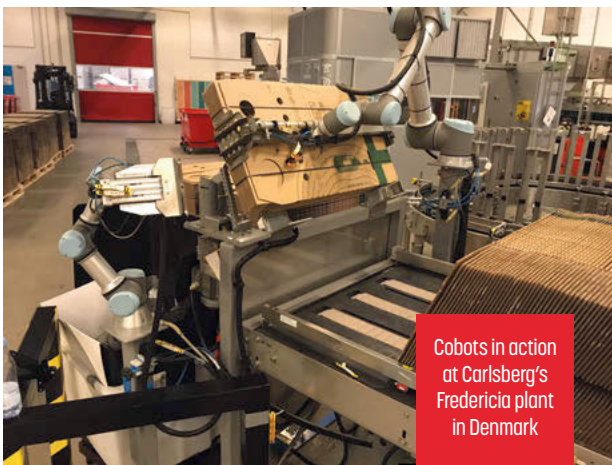
MG: I think the biggest evolution won't be in the technology itself but in its

adoption, especially by SMEs. The UK has traditionally been slow to adopt robots. However, things are rapidly changing as the twin challenges of productivity and labour shortages continue to drive companies to seriously consider automation.

To accelerate this adoption, Universal Robots recently announced a cobot leasing programme that reduces the up-front costs of automating still further. I think this will prove significant as it removes one of the final barriers for companies that want to make the leap to automation. Cobots typically pay back their costs in less than a year meaning once companies have taken that first step it quickly becomes cost-effective to deploy more.

SS: Increasing deployment flexibility is a key part of cobotics evolution. Combining cobots with AGVs creates a highly adaptable, mobile assistive resource. Powerful, yet simple user interfaces will enable rapid re-deployment according to demand. This will be supported by apps libraries, making it easier to describe the task required rather than having to program the individual movements. Inevitably this will all be assisted by AI algorithms for performance optimisation, collision and fault avoidance and preventative maintenance. **#ENGINEER**

/// FALLING PRICES ARE A KEY COMMERCIAL TREND ///
Steve Sands, Festo GB



Cobots in action at Carlsberg's Fredericia plant in Denmark



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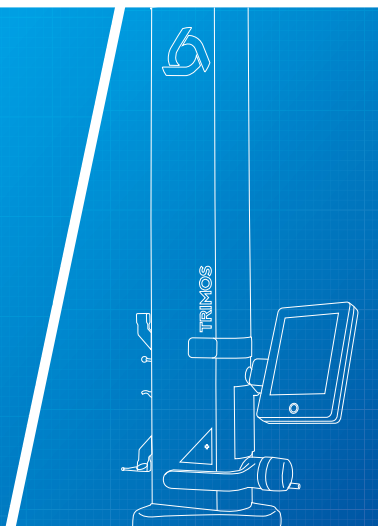
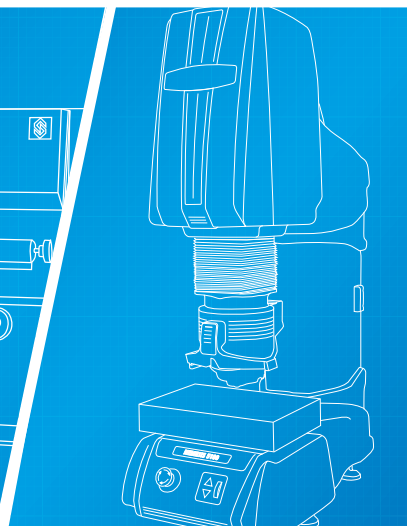
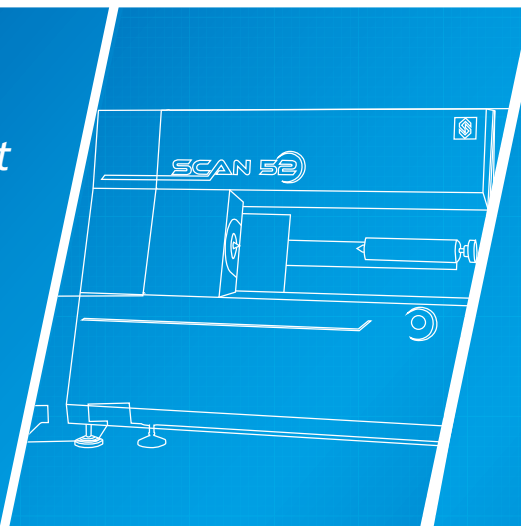
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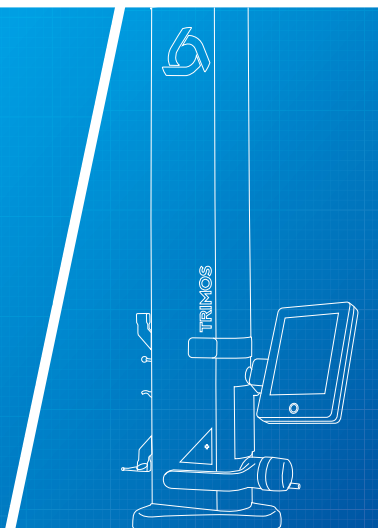
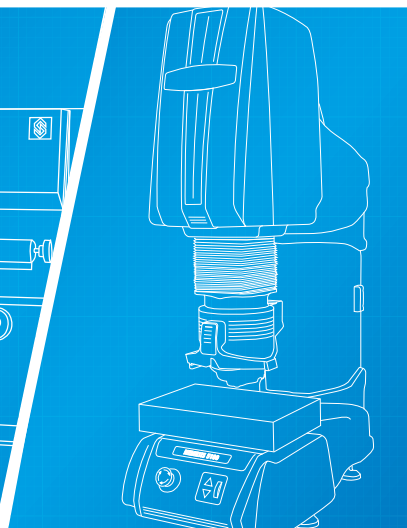
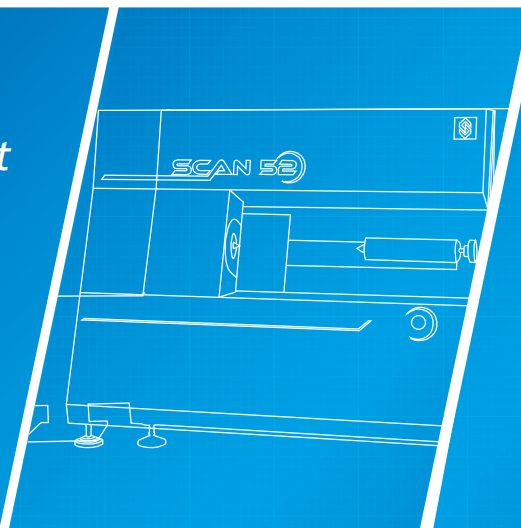
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ROBERT STEPHENSON: ROCKET MAN

Designer of the pioneering Rocket that was to set the blueprint for the trains of the future, Robert Stephenson's career was also influential in the field of Victorian bridge-building.

WRITTEN BY NICK SMITH

In an early biography of the Stephenson father-and-son engineering dynasty, Samuel Smiles recalls the great railway and civil engineer Robert Stephenson doubting whether the public would be interested in reading about the life of his father George. "If people get a railroad," he is reported to have said, "it is all they want; they do not care how or by whom it is done."

And yet, the son co-operated in the production of a book that became a Victorian best seller and helped forge the unbreakable association between the name Stephenson and railway engineering. Although often attributed to his father, arguably the most famous locomotive ever built – Rocket – was designed by the son. It's a common confusion arising from the fact that, as David Ross says in his 21st century double-header biography of the two men, to write about one without reference to the other is 'impossible'. But for all the locomotives and railway line surveys, ultimately, Robert Stephenson's legacy is founded on his prowess as a bridge-builder, most notably the Britannia Bridge over the Menai Strait in North Wales.

Born on 16th October 1803 in Northumberland, Robert Stephenson's early life displayed few clues that he would become one of the greatest engineers of the 19th century. While his father George had been born to poor and illiterate parents (George was himself illiterate until the age of 18), Robert's start in life was only marginally better. His father was a brakesman at the local colliery, and by the time he was three, his



ROBERT STEPHENSON 1803-1859

mother Agnes had died of tuberculosis. The infant Robert was subsequently left with a housekeeper while George departed for Scotland to look for work, eventually returning to the colliery at Killingworth, where he became an expert in steam machinery: the first step in an illustrious career that would make him 'Father of Railways'. Despite having little formal education, George was determined that his son would benefit from one, and at the age of 11, Robert was sent to the Percy Street Academy in Newcastle, where he borrowed books that he would study with his father. In 1813, Robert was apprenticed to a local colliery manager, during which time he constructed a mining compass that he would later use to survey the High Level Bridge in Newcastle upon Tyne.

While Robert was still an apprentice, his father became involved with surveying on the proposed Stockton and Darlington Railway (S&DR). With Robert showing signs of the

illness that had accounted for his mother, he was released from his apprenticeship and went to work with his father. After the initial private bill for the S&DR failed before parliament, amendments were made to the route by the father-and-son team with the result that a subsequent bill was passed. George Stephenson, who had recommended the use of steam locomotives, was elected engineer for the project on a yearly salary of £660 that allowed him to send Robert to Edinburgh University (albeit for a less than a year), where he studied natural philosophy, natural history and science. By May 1823 final assent from parliament allowing the use of 'loco-motives or moveable engines'. The following month Robert Stephenson & Co was established to build them, with Robert borrowing £500 to pay for his share in the company, a sum that dwarfed his £200 annual salary. By 1824 the S&DR had ordered two steam locomotives and two stationary engines from Robert Stephenson & Co, and the line opened in September 1825.

Robert was not there to see it because by June 1824 he was sailing to South America to oversee the installation of steam machinery in the gold and silver mines newly reopened by the Columbian Mining Association. Robert's motive for taking up an appointment on the other side of the world has divided historians, who have seen his departure from the locomotive company as either because of a disagreement between the Stephensons over financial matters, or an indication that Robert was trying to break free from his father's orbit. Either way, the trip could hardly be described as

➔ Opening of the Liverpool and Manchester Railway, Liverpool, 1830

a success, with illness, labour problems and even a shipwreck thwarting the enterprise. After a brief tour of north America he returned to Britain where he resumed his role managing director of Robert Stephenson & Co, working on locomotive design – notably on Experiment and Lancashire Witch – as well as surveying railway routes and consulting on a tunnel under the River Mersey.

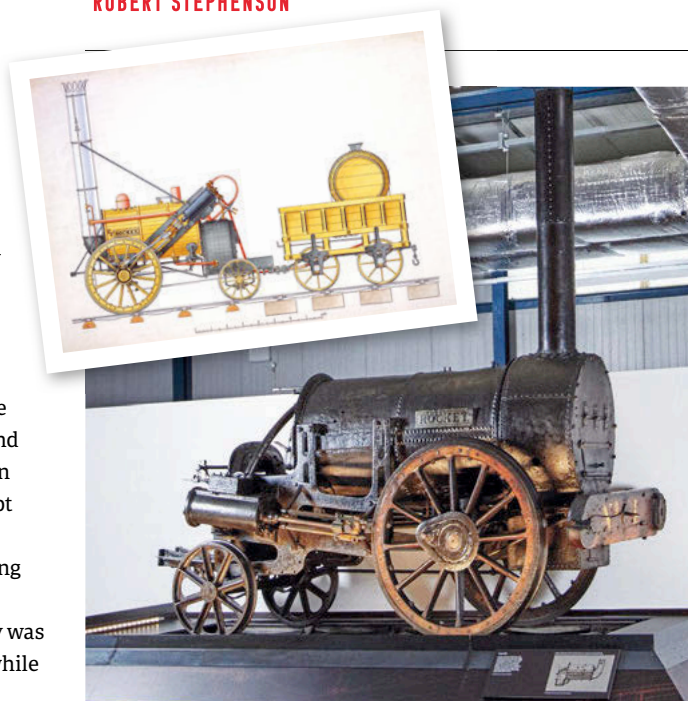
But it was the steam locomotive Rocket that was to be his career landmark of the decade. Designed by Robert and built at Robert Stephenson & Co's Forth Street works in Newcastle, Rocket was by no means the first steam locomotive, despite its reputation for being so. But it was the most technologically advanced design of the time, bringing together several innovations that would establish the template for the steam locomotive for the following century. Rocket – how or when it got its name is unclear – was designed to take part in trials being conducted by the Liverpool and Manchester Railway (L&MR) at Rainhill. Because the line was intended as a predominantly passenger (rather than freight) service, the rules for the competition gave priority to speed and reliability. With weight restrictions in place, a key design decision was to opt for a single pair of drive wheels (the format of Rocket is 0-2-2, ie two driving wheels, two trailing wheels and no leading wheels). Increased efficiency was achieved by a multi-tubular boiler, while other innovations included close-to-horizontal pistons connecting directly to the drive wheels, and a separate firebox.

Rocket won the competition. The L&MR purchased it and placed an order for four similar units and the line opened on 15th September 1830 in the presence of the Duke of Wellington. This was somewhat overshadowed by the Member of Parliament for Liverpool William Huskisson becoming the first verifiable railway passenger fatality, having been run over by Rocket in a bizarre sequence of events. The resulting coverage of the



/// IF PEOPLE GET A RAILROAD, IT IS ALL THEY WANT; THEY DO NOT CARE HOW OR BY WHOM IT IS DONE. ///

ROBERT STEPHENSON



➔ Steam locomotive 'Rocket' on display at the National Railway Museum, illustration of Stephenson's 'Rocket', 1829.

accident, however, drew the public's attention this new long-distance passenger transport technology.

Running parallel to Robert Stephenson & Co (and with the same directors) was the firm George Stephenson & Son that was contracted to survey a railway route from London to Birmingham. Still in his late twenties, on 20th September 1833 Robert signed the contract to build the 112-mile line from Camden Town to Birmingham on an annual salary of £1500, following which he moved to London, where he later

established offices next door to the Institution of Civil Engineers and had the Herald's College draw him up a coat of arms. Consolidation of his career as a railway entrepreneur came in the form of a long list of largely forgotten projects, including advising King Leopold on the Belgian State Railway (for which he was decorated with the Order of Leopold), an ill-fated investment in the Stanhope & Tyne Railroad Company, as well as advising on railways in France, Spain and Italy.

Robert was also the builder of many long-span railway bridges, of which the jewel in the crown is the Britannia Bridge that connects the island of Anglesey with mainland north Wales. A rivetted tubular bridge of wrought iron rectangular box-section spans supported by stone piers (the central one built on Britannia Rock), the specification insisted on by the Admiralty required the arches to be of sufficient height (100ft) to allow a fully rigged man-of-war to pass beneath. Robert borrowed the construction method from contemporary ship-building techniques and, to commemorate the structure's completion, personally fitted the last rivet in 1850, a year after Queen Victoria opened his High Level Bridge in Newcastle.

Robert Stephenson spent the remainder of his career as the Conservative Member of Parliament for Whitby, his maiden speech in the House being in favour of the Great Exhibition of 1851 (of which he was a commissioner, alongside his friend Isambard Kingdom Brunel), and later speaking against Britain's involvement in the Suez Canal scheme. At the height of his fame, he was also suffering from Bright's Disease (chronic nephritis), which meant that he found the attention from prospective investors overbearing and would retreat to his yacht Titania, describing it as 'the house that has no knocker.' Returning to Britain from Oslo on Titania in 1859 he became seriously ill and died on 12th October 1859, merely days after the passing of Brunel. Such was the national impact of Robert's death, Queen Victoria broke with protocol and granted his funeral cortège passage through Hyde Park, an honour traditionally reserved for royalty. #ENGINEER

MARCH 1960

Current thinking

More than twenty years before it became operational The Engineer reported on some early designs for the Thames Flood Barrier

WRITTEN BY JASON FORD

The tidal surge that struck the east coast of Britain in 1953 left London relatively unscathed but rattled enough for authorities to call for proposals for a Thames flood barrier.

The extreme weather event struck on January 31, claiming 326 lives in the UK and wreaking devastation along the coastlines of Belgium and the Netherlands.

London knew it had got off lightly. In 1928 a storm surge played a significant part in flooding that reached central London, killing 14 and rendering thousands homeless. Parts of the capital are said to have been under 1.2m of floodwater, which brought down embankments and infiltrated the House of Commons, Tate Gallery, London Underground stations and numerous dwellings.

A similar situation was avoided in 1953 as the surge did not quite coincide with the high tide in the Thames estuary, and the upland flow at the time was low.

The river did, however, lap the parapets of embankments in central London and a slightly higher level would have caused extensive flooding in riverside enclaves from Woolwich and Greenwich in the east to Fulham and Bermondsey in the west of London.

London's current protections against a tidal surge include 350km of flood walls and embankments, pumping stations, flood gates and the Thames Barrier, a London landmark officially opened in 1984 and built across 520m of the river from Silverton on the north bank to New Charlton on the south bank.

Work began at the Thames Barrier site in 1974 following several years of deliberation about the type of moveable barrier to be built and the best place to put it. Discussions about the barrier began in the aftermath of the 1953 surge, and in March 1960 The Engineer reported on designs put forward for consideration following the publication of a report titled Technical Possibilities of a Thames Flood Barrier, which had been presented to Parliament by the minister of housing and local government.

The report called upon the services of consulting engineers Messrs Rendel, Palmer and Tritton; and Sir

Bruce White, Wolfe Barry and Partners to consider the feasibility of a moveable barrier across the Thames at Long Reach.

"For navigation, an unobstructed fairway was clearly considered preferable, but it was suggested that the specification should call for two clear central spans each of 500ft, with a vertical clearance of 220ft, with the barrier not in use," noted The Engineer. "Side spans would cater for barges and light traffic, dimensions of not less than 250ft span and 50ft clearance being suggested. Protection against surge levels 6ft higher than those experienced in the 1953 disaster was specified."

Everyone agreed that that the barrier should be capable of closing the river against a tidal current of 7ft per second, offer the least obstruction to shipping in its open position, and not cause undue silting or scouring of the riverbed. Similarly, the barrier would withstand a differential head of 20ft with a maximum depth of water on the downstream side of 65ft, and 'must be dependable in operation, and the operating gear must be readily accessible.'

Six forms of barrier were considered, including hinged gate types, either of the mitre or straight sill design; a bascule version with rising girder spans; and a permanently submerged type, which would be housed on the riverbed and would rise up from the bed when closure was necessary.

A version of the latter now controls the river flow of the Thames, but the design was rejected in 1960.

"The submerged type was attractive as no piers would be required in the river and, as it would be housed on the riverbed on a prepared base, there would be no obstruction to shipping," The Engineer said. "The barrier, however, would be subject to corrosion and special measures would have to be taken on that account. The working parts would be inaccessible, and there would be no knowing whether silting had occurred or whether the barrier was in





immediate readiness to be brought into operation. Any work that might have to be done on the barrier would have to be by divers or by diving bell or complete sections would have to be floated away to a dry dock.”

The consultants also rejected the bascule idea because ‘the problem of providing adequate anchorage for the bascule spans would be tremendous and would be likely to rule out such a scheme.’

Similarly, attempts to build swing and mitre gates to suit large openings had proven unsatisfactory for various reasons. “To keep the pintle loads reasonably low, the gates would have to include buoyancy chambers, and the swinging of the structure into position in a strong tide would involve opposing the force of the river through the barrier handling mechanism,” said our correspondent. “The forces to be controlled would be of a high order and would need to be applied through considerable distances.” **#ENGINEER**

Flood of ideas

The design for the current Thames barrier (picture) - which uses submerged gates that rise from the riverbed - was originally rejected due to concerns about corrosion and maintenance



We live in a time of great uncertainty, with a rising population and changing climate, and many worst-case projections seem increasingly likely to come to pass. But that doesn't mean we should give up hope. After all, engineering is all about finding solutions to problems, and what greater problem could we face than the extinction of our species!

To counter all the doom and gloom, I decided this month to look ahead to a world where political and industrial inertia have been conquered, and engineers set free to tackle the challenges ahead. So, come with me to the world of 2100 AD. Many of our children and grandchildren are still alive, but their way of life is as different to ours as ours is to that of the Victorians.

Cities are greener spaces. Trees line the centre of every street; vertical gardens adorn the south side of every building; and solar panels cover every roof. There's very little traffic noise or pollution, because all the cars are self-driving electric models and most people travel by clean and affordable public transport.

Much of the Green Belt surrounding the cities has been turned over to agriculture, most of which is fully automated, while huge reforestation programmes have returned the wilds of Wales, Scotland and the Lake District to the densely wooded state they enjoyed in the wake of the last ice age.

You don't see many cows, chickens, sheep or pigs anymore. Ninety-nine percent of the meat in our diet is grown in vats, cloned from the finest animals and produced with minimal environmental impact. It's also healthier, requiring fewer of the medicines and hormones currently pumped into our food animals.

International travel is rarer than before. Business can be done online and via video link. There



GARETH L. POWELL

Our grandchildren's world

A bleak, dystopian future isn't inevitable. Resident science fiction writer Gareth L. Powell offers a more encouraging vision of how technology, and engineers, might shape our grandchildren's world.

are still a few airliners, but they now use biofuels. The majority of passengers and freight travel via airship or wind-powered sea-going vessels.

Overhead, vast tissue-thin orbital mirrors reduce the amount of heat reaching the Earth from the Sun. Space tourism never really took off (if you'll pardon the pun), but microgravity turned out to be a great place for science and manufacturing, and there are

now several large commercial and government space stations in orbit, along with power satellites that collect the sun's rays and beam them down to earth as microwaves, to collectors on the equator, that then make them available as clean, unlimited electrical power.

Looking down from one of these satellites, parts of the Pacific and the Sahara shimmer with huge solar farms. Floating wind turbines harvest the jet streams, and even

the ocean's tides provide us with the energy we need.

But it isn't all good news. Some climate change was inevitable. It took us too long to act and respond.

Storms are worse and more frequent. New York now exists below sea level, protected from inundation by a huge sea wall. Other cities have been less fortunate. Venice has become a modern-day Atlantis, and much of Central London floods twice a day at high tide. But people are adapting. Huge infrastructure projects aim to reclaim land from the sea. Climate refugees move north from the scorching equator, seeking shelter in the newly temperate open spaces of Russia and Canada. The population of Greenland is rising at an incredible rate, and there are even some hardy souls scraping a living from the exposed soil on the fringes of Antarctica.

A failed attempt to colonise Mars has shown the world's billionaires that it's easier to terraform the Earth than try to adapt the red planet to our needs. So now, they've thrown their resources into projects that benefit us all, rather than just themselves—including the development of artificial intelligence capable of regulating the Earth as a single organism, moving food, clean water and other assets to where they are needed, while simultaneously managing the balance of gasses in our atmosphere through carbon capture projects, and the global mean temperature, through manipulation of those solar mirrors I mentioned earlier.

Instead of ransacking the Earth for resources and financial gain, humans have become stewards of their world, engineering the planet for its ten billion inhabitants. Yes, there are still problems, and yes, much of the above is pure speculation—but speaking as an author, of the two possible fates awaiting us, I know which one I would rather write about. **THEENGINEER**

// VAST TISSUE-THIN ORBITAL MIRRORS REDUCE THE AMOUNT OF HEAT REACHING THE EARTH FROM THE SUN //



Daniila Shtantsou/stock.adobe.com



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HOW THE MODERN WORKPLACE DULLS CREATIVITY

From open plan offices, to enforced corporate “fun” our anonymous blogger bemoans the creativity dulling blandness of the modern engineering workplace

There seems to be a continuing trend within companies I work for to quash all aspects of individuality in the pursuit of some kind of insidious anaemic uniformity. This has taken various guises over the years but continues to spread in both scope and ubiquity.

I remember that when I started in engineering our D.O. effectively consisted of “cells” of 4 boards each: 2 boards facing each other, a walkway then another two boards similarly arranged, desks with layout tables and bookcases forming the perimeter. Each of these “cells” was adjoined by another all the way down the office. There were partitions to which reference information or personal pictures could be pinned and if not a clean desk policy at least encouragement was given to keep surfaces fairly clear although, again, personal items often found a home here. Everyone dressed smartly if informally when compared to those you may find inhabiting similar surroundings in black and white documentaries. Ties were rare but sober shirts, blouses, skirts or trousers were the norm. There was an air of undoubted professionalism but also fun and creativity – the latter I think with hindsight in no small way because we had certain latitudes. We enjoyed the minor freedoms that being respected professionals earned.

I remember too the nascent cries of “PC culture” when the edict came around that all girly calendars were to be removed. I didn’t mind that as a policy, apart from personal mores the ever present call for greater numbers of women in engineering never

seemed to sit happily with intrinsically intimidating and exclusionary lad culture.

Time passed and as I moved from job to job I saw a trend in the evolution of companies and, within those, departmental culture. As the wall came down in Berlin, walls came down in office blocks across Britain to allow the grouping of departments into the industrial battery hen shed that is “the open plan office.” I didn’t particularly notice any increased fraternisation between departments, the entirely laudable aim usually trotted out

for such moves, when compared to a well planned set of discrete offices. I did, however, notice a lot more annoying background noise as I was trying to work. Others are more reliant on shouting into phones than us and have a correspondingly lesser need for occasional aural-centric isolationism.

Each step away from defined departments was accompanied by a step towards personal homogeneity. The clean carpets, freshly painted walls and matching desks were welcome; the strictly enforced clean

desk policies and prohibition on personal pictures less so. There now seems to be a general move onto the next stage of assimilation as I’m hearing of companies where the corporate uniform is mandatory throughout and all screen “wallpapers” are locked into displaying the approved company logo. Finally every department blends indistinguishably into the next and, as the drawing board has only resided in museums for some years, nothing remains to separate us from accountant, storeman, sales rep or the person organising the cleaning rota. Nothing wrong with those activities but the pride in our department and in our position within the company, whether delusional or not, seems to have bled away.

Other changes in the workplace over the past 40 years or so may have made a more immediate and quantifiable impact but I wonder what this is all for, and whether it really is the right way to go? Whatever the reality may have been, where I once felt personally invested in the company by having my own little part of it I now feel like an interchangeable drone. Without the friendly rivalry with other, clearly separate, departments the team ethos has become noticeably diluted. I see it as no coincidence that a rise in team building courses and faux fun in the workplace has gone hand in hand with this promulgation of all encompassing blandness. I used to find pride and excitement intrinsically woven into my work environment and culture, now these feelings are only evoked in a minor way through artifice. **THEENGINEER**





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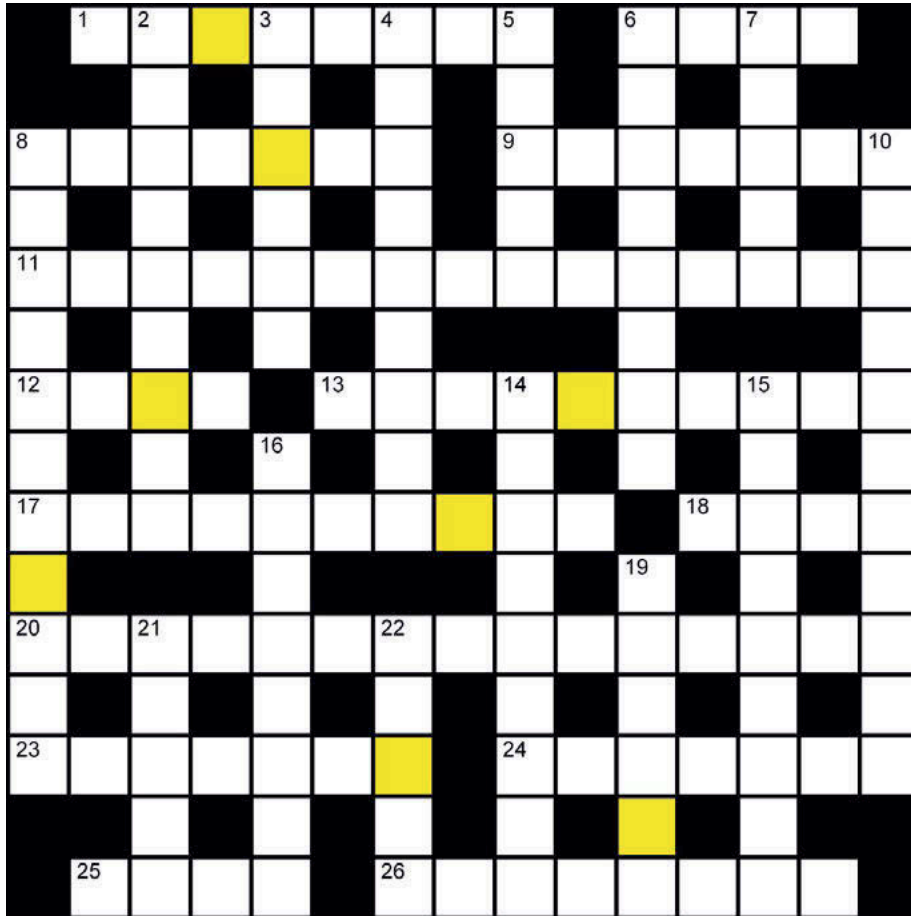
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Across

- 1 Electrical junctions (8)
- 6 Substance that can be consumed to produce energy (4)
- 8 Put things in order (5,2)
- 9 Parallelogram with four equal sides (7)
- 11 Unit of rate of work equal to 746 watts (5,10)
- 12 Machine for weaving (4)
- 13 Moulding around a door or window (10)
- 17 Message visible from a road (6,4)
- 18 Large room for gatherings or entertainment (4)
- 20 Controlling software on a computer (9,6)
- 23 Carving a design into (7)
- 24 Large passenger vehicle (7)
- 25 Conduit to carry off smoke (4)
- 26 Fortified with ditches (8)

Down

- 2 Patron of dramas set to music (5,4)
- 3 Boat for communication between ship and shore (6)
- 4 Cabinets used for storage space (9)
- 5 Irrational numbers (5)
- 6 Paved area for pedestrians (8)
- 7 Length of pipe with a sharp bend in it (5)
- 8 Block once used to make roads (11)
- 10 Illumination along roadways (6,5)
- 14 Surpassing in quality (4-5)
- 15 Capable of being made suitable for a task (9)
- 16 Having a similar charge as electrons (8)
- 19 Beyond ordinary understanding (6)
- 21 Distinguish oneself (5)
- 22 Block of cast metal (5)

When completed rearrange the highlighted squares to spell out a process of initiating combustion. The first correct answer received will win a £20 Amazon voucher. Email your answer to jon.excell@markallengroup.com

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