164 YEARS OF TECHNOLOGY AND INNOVATION WWW.THEENGINEER.CO.UK

THE ENGINEER

JANUARY 2020

Green machines

The technologies powering a precision farming revolution and helping to redraw the agricultural landscape

26 **STEADY HANDS:** HOW A UK DEVELOPED ROBOT COULD BRING LAPAROSCOPIC SURGERY TO THE MASSES

42 **IN THE FRAME:** 3D PRINTING TECHNOLOGY MAKES ITS MARK ON BICYCLE MANUFACTURE

50 **LATE GREAT ENGINEERS:** THE LIFE AND TIMES OF HILDA LYON - AIRSHIP PIONEER AND AERODYNAMICIST

TheEngineerUK
theengineeruk
The Engineer UK

Engineering Skills for a Smarter World

A new engineering skills organisation, innovating to develop the skills we all need to succeed, today and tomorrow.

Charlie Blair
Managing Director
Gravitricity Ltd

Charlie is developing a novel energy storage technology, to help the grid maximise the energy revolution in renewables, while giving disused mineshafts a new lease of life.

Gravitricity's patented technology is based on a simple principle; raising and lowering a heavy weight to store and release energy.

During times of high renewable energy generation and low demand, electricity turns motors to lift a weight of up to 5000 tonnes.

During high demand but low generation the system reverses, dropping the weight to turn generators within the winches, returning electricity to the grid.

Robyn Clarke
Undergraduate Quality Assurance Engineer
Toyota Motor Manufacturing (UK) Ltd

Robyn has been a real trailblazer at Toyota Motor Manufacturing (UK) Ltd. She has often been the first to engage with skills development programmes, paving the way for other young engineers, especially women, to follow in her footsteps.

Because Robyn felt she initially lacked support with regards to her career options, she's now a passionate STEM ambassador, encouraging young people to consider a career in engineering.

She also represented the UK in WorldSkills Sao Paulo 2015 in the Mechatronics competition, where she was awarded a medallion of excellence.

02/20

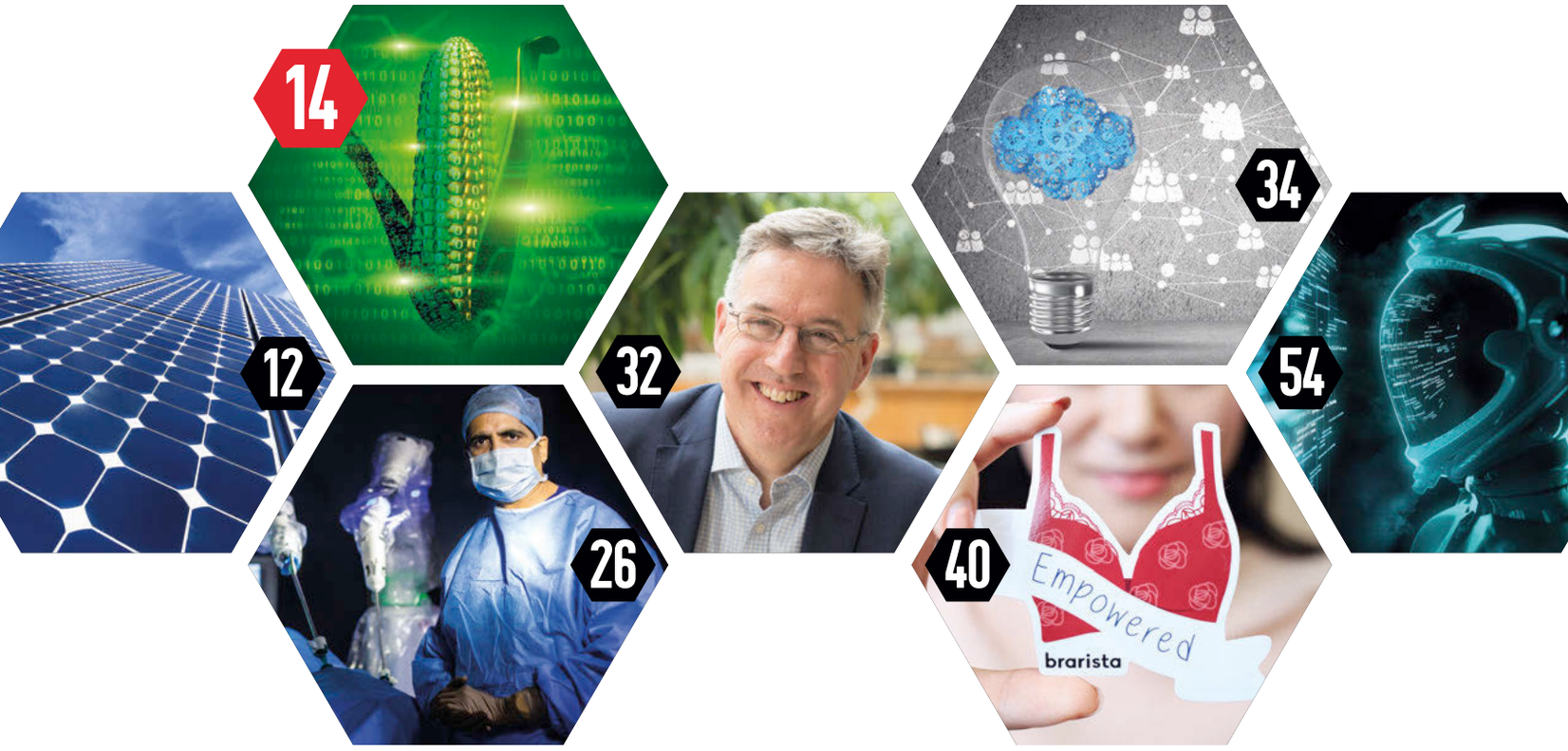
Given the opportunity, one engineer can change their world and ours.


There's a reason
Managing Safely
doesn't cut corners
The consequences of rushing health and safety training can be fatal. So *Managing Safely* takes exactly the right amount of time to get participants up to speed. That's why our three day health and safety course is the most popular for line managers, in any sector, worldwide.
iosh Managing Safely
Tried. Tested. Trusted.
www.iosh.com/managingsafely

CONTENTS

ESTABLISHED 1856
163 YEARS OF TECHNOLOGY & INNOVATION

VOLUME 300 • ISSUE 7913 • JANUARY 2020



7 EDITOR'S COMMENT
From the farm to the operating theatre few areas of industrial endeavour are untouched by digitalisation

8 NEWS
UK developed Hyperloop-style maglev delivery system promises an end to road freight congestion

12 BUSINESS NEWS
Bombardier sells Belfast plant to Spirit Aero Systems in $1 billion deal

13 NEWS ANALYSIS
The African engineering entrepreneurs turning problems into opportunities

14 COVER FEATURE
Precision farming technologies ranging from drones to robots are driving a new agricultural revolution

20 VIEWPOINT
GODAN's Andre Laperriere talks agritech innovation

22 TALKING POINT
Have we reached the electric vehicle tipping point?

30 MAILBOX
The Bloodhound effect and fresh warnings on sea-level rises

26 MEDICAL TECHNOLOGY
How Cambridge medical robot firm CMR Surgical hopes to bring laparoscopic surgery to the masses

32 INTERVIEW
Babcock technology MD Jon Hall on using digitalisation to drive innovation

34 ROUNDTABLE REPORT
An expert panel discusses the challenges and rewards of collaboration

40 ENTREPRENEURS
Bringing machine vision and AI to bear on the challenge of bra-sizing

42 CONSUMER TECH
Additive manufacturing is beginning to make an impact in the exacting world of bicycle manufacture

46 PRODUCT FEATURE
3D printing experts offer their perspectives on key industry trends

50 LATE GREAT ENGINEERS
Aeronautical pioneer and airship engineer Hilda Lyon

54 SCI FI EYE
Gareth L Powell speculates on future applications of exoskeletons and implantable electronics

COVER ILLUSTRATION: *Oliver Burston*

THE ENGINEER

MARK ALLEN GROUP
Mark Allen Group, St Jude's Church, Dulwich Road, London, SE24 0PB
www.markallengroup.com

ISSN 0013-7758. Printed by Pensord, Press Ltd, Blackwood, NP12 2YA

Editor **Jon Excell**
+44 (0)20 7738 5454
jon.excell@markallengroup.com

Features editor **Stuart Nathan**
+44 (0)20 7738 5454
stuart.nathan@markallengroup.com

Senior reporter **Andrew Wade**
+44 (0)20 7738 5454 andrew.wade@markallengroup.com

News editor **Jason Ford**
+44 (0)20 7738 5454
jason.ford@markallengroup.com

Commercial director **Justyn Gidley**
+44 (0)20 7738 5454
justyn.gidley@markallengroup.com

Business development manager **Paul Tilston**
+44 (0)20 7738 5454

Senior account manager **Lindsay Smith**
+44 (0)20 7738 5454

Art Director **Andrew Ganassin**
andrew.ganassin@markallengroup.com

Production **Kyri Apostolou**
+44 (0)20 807 6779
kyri.apostolou@markallengroup.com

Publishing director **Luke Webster**
01722 714847
luke.webster@markallengroup.com

Subscriptions & Customer Services
circulation@markallengroup.com

The Engineer is available for International licensing and syndication.
For more information please email luke.webster@markallengroup.com

News 020 8076 0576
Display 020 8076 0582
Recruitment 020 8076 0581

UK subscriptions £75 pa UK/£117 pa overseas.
Contact **comments@ theengineer.co.uk.**

Visit **www.theengineer.co.uk** for constantly updated news, products and jobs and to sign up for our FREE weekly email newsletter and tailored job alert

SCAN ME

JON EXCELL

Dig the new breed

Few areas of industrial endeavour are untouched by digitalisation. And in this issue there are three striking examples, from three very different sectors, of how a smart approach to data is improving performance and driving innovation.

Perhaps the most eye-catching illustration comes in our cover story (page 14) which explores the technologies at the heart of what some are referring to as the 4th agricultural revolution.

Engineering and agriculture have long gone hand in hand. Indeed, the earliest issues of this publication were dominated by stories of innovative ploughs and elegant harvesting machines.

But now agriculture is being reshaped by a new wave of digital innovations - far removed from the heavy mechanisation of the Victorian era - in which armies of data-gathering drones and soft robots are helping farmers carefully target the use of fertilisers and pesticides, enabling them to reverse a worrying decline in crop yields whilst improving biodiversity.

Elsewhere in this issue (page 26) we show how data is poised to transform the world of surgery, as we take a look at one of the UK's most exciting emerging medical technology firms: CMR Surgical.

The firm's robot arm – developed to bring the benefits of keyhole surgery to the masses – is an impressive piece of hardware in its own right. But as we hear, the ability to gather data on how it's being used in order to optimise training on the system, will be key to ensuring that the benefits of robotic surgery aren't just reserved for the the richest members of our society.

Finally, in this issue's interview (page 32) we hear from Jon Hall, technology MD at engineering giant Babcock International Group, about the role digitalisation is playing in squeezing ever greater levels of performance out of assets ranging from Royal Navy warships to nuclear power stations and even fire-fighting UAVs.

As the features in this issue remind us, engineering innovation - whether it's destined for the high seas, the operating theatre or the farmer's field - is increasingly reliant on the intelligent use of data. And, as we look further ahead, the degree to which this drives different sectors to collaborate and learn from each other will surely become one of the defining characteristics of modern engineering.

Jon Excell

EDITOR • JON.EXCELL@MARKALLENGROUP.COM

READ MORE ONLINE

Bloodhound LSR in South Africa; the pros and cons of electric cars; and aerial firefighting technology

www.theengineer.co.uk

follow us at

@TheEngineerUK

theengineeruk

The Engineer UK

The Engineer UK

ENGINEER JOBS

Find your next engineering job online at The EngineerJobs

SCAN ME

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.

5 THINGS WE'VE LEARNT THIS ISSUE

1. 90 per cent of agricultural chemicals and fertilisers are used unnecessarily
2. The Fiat / Peugeot merger has created the world's fourth largest car maker
3. 45 per cent of readers are put off electric vehicles by charging concerns
4. Approx 6 million patients a year miss out on the benefits of Keyhole surgery
5. Advances in 3D printing technology are making carbon fibre bicycles more affordable

The right choice of welding gas can increase productivity by 30%

See the Bigger Picture with Maxx® welding gas

airproducts.co.uk/maxx

AIR PRODUCTS

NEWS

Follow us at:
@TheEngineerUK
theengineeruk
The Engineer UK
The Engineer UK

WWW.THEENGINEER.CO.UK

Magnetic delivery concept could slash road congestion

Tunnel network and linear motors promise to deliver the goods

JON EXCELL REPORTS

A hyperloop-inspired goods delivery concept that uses linear motors to propel crates along a nationwide network of pipes could help remove polluting freight traffic from roads and revolutionise the delivery of goods.

This is the claim of Magway, a London based-start up behind the scheme that has already received almost £1.5m of seed funding and grants since it was founded in 2017, including a £650,000 grant secured from Innovate UK. The company now hopes to raise a further £750,000 through a fresh wave of crowdfunding.

The company's co-founder and technical director Rupert Cruise told *The Engineer* that the concept initially sprung out of growing interest in Hyperloop, the high speed transportation concept originally proposed by Tesla founder Elon Musk (and now being developed by Virgin Hyperloop One) that will use linear electric motors to accelerate passenger pods through low pressure tubes.

He said Magway is simpler to commercialise, primarily because it's not transporting people at supersonic speeds and it doesn't require a vacuum.

The system uses a magnetic wave of electrical current, generated by highly efficient linear synchronous magnetic motors to drive multiple, standard-sized crates (or totes) along a track. Travelling at an optimal speed of 31mph, and just milliseconds apart, the totes are propelled through a network of new and existing underground, overground and even suspended 0.9m diameter HDPE pipes that would run alongside existing road and rail routes.

Cruise said that the system has been designed to interface with the highly automated warehouses operated by organisations like Ocado and Amazon, which, while highly efficient in the warehouse, still rely on fleets of trucks and vans to get their products to customers.

He added that the crates carried on the Magway system are roughly the same dimensions as the totes used by these retailers so it could be very easily integrated with their systems. Indeed, Ocado Innovation Limited, along with the Transport Research Laboratory (TRL) and linear motors specialist Force Engineering, was one of the partners in the Innovate UK funded project.

The team has already built demonstration versions of the system at its test facility in London and is now in the process of identifying sites for commercial scale pilot.

Initial commercial applications are likely to focus on short delivery routes in and out of hubs such as airports, said Cruise, but the firm's ultimate vision is to construct a UK-wide network of tubes.

Modelling has identified where UK demand will be highest for the system, and has, he claimed, shown that 94 per cent of London's daytime population could be within a 15-minute walk or cycle of a Magway node.

If the technology is deployed at the scale envisaged by the company it could eliminate millions of tonnes of CO_2 emissions annually.

Read more at www.theengineer.co.uk

Read more online

AEROSPACE
- German team begins tests of aeroelastic wing technology

AUTOMOTIVE
- Guy Martin drives Fastrac tractor into the record books

CIVIL & STRUCTURAL
- Swiss team develops more sustainable reinforced concrete

ELECTRONICS & COMMUNICATIONS
- Drone mounted scanner can see through walls
- VR system gives sense of touch to video calls

ENERGY & ENVIRONMENT
- Belfast team turns brewery waste into valuable carbon

MEDICAL & HEALTHCARE
- Brain implant electrode material shows MRI compatibility

SKILLS & CAREERS
- Engineering is fifth most trusted profession in UK

Jobs online

NEWS IN BRIEF

SPACEPORT FOR CORNWALL

Virgin Orbit UK will receive £7.35m from the UK Space Agency to develop facilities for its planned spaceport at Cornwall's Newquay Airport. According to the UK Space Agency, the UK subsidiary of Virgin Orbit will use the funds to develop advanced ground support equipment and conduct mission planning. The first horizontal launch of small satellites from the site is planned for the early 2020s, subject to regulatory approvals.

FRACKING FLOUNDERS

The government has suspended fracking following the publication of a report by the Oil and Gas Authority (OGA) warning of earthquake risks. Fracking, which uses high pressure fluids to create cracks in sub-surface rocks to release trapped gas, will not be allowed to proceed in England until new evidence shows the process is safe. OGA found that it is not currently possible to accurately predict the probability or magnitude of earthquakes linked to fracking.

SOLAR SOLUTIONS

A US start-up backed by Bill Gates is targeting solar thermal energy hitting 1,500°C that can transform carbon-heavy industrial processes and create zero-carbon fuels. Heliogen uses advanced computer vision software to precisely align a large array of mirrors to reflect sunlight to a single target. The California-based company claims it has already used this technology to achieve temperatures greater than 1,000°C, which is hot enough to replace fossil fuels in the production of steel and cement.

Read more at www.theengineer.co.uk

Back-contact perovskite solar cells target greater efficiency

Project tackles dual challenges of output and manufacturability

DAVID FOWLER REPORTS

Solar cells could become more efficient and cheaper to mass-produce as a result of an EPSRC-funded research project at St Andrew's University.

The project, led by research fellow Dr Jonathon Harwell of the university's physics and astronomy department, aims to develop a back-contact perovskite solar cell (PSC). Perovskite describes a type of crystal structure, but in solar cells refers specifically to lead-halide perovskite, which has electrical properties similar to silicon. But whereas silicon must be grown slowly as crystals at temperatures of over 1000°C, perovskite can be crystallised out of a solution of two inexpensive raw materials and deposited by methods including printing.

Consequently, PSCs have the potential to be flexible, thinner and cheaper than silicon solar cells, with similar efficiency and lower manufacturing costs.

Perovskite solar cells are currently made as a sandwich, with the solar absorbing layer between two conducting layers for collecting positive and negative charge respectively. The top layer must be transparent and conductive. Currently indium tin oxide is used, which is expensive and rigid. Because the light must pass through the ITO layer before it reaches the absorber, efficiency is also reduced.

Harwell's key aim is to produce a back-contact cell – with both sets of conductors on the back of the absorber. This can be achieved using conductors shaped as interlocking metal fingers (with different coatings to make them selectively absorb positive or negative charges). However, the spacing of the fingers must be similar to the thickness of the absorber. For a typical silicon wafer this distance is around 50µm, but for perovskite it is 300nm. So far, no cost-effective or scalable way to fabricate the contacts at this size has been found.

Harwell had previously made diffraction gratings for lasers with features of a similar scale. The gratings were produced using nanoimprint lithography, in which a master "stamp" imprints the pattern into a hard polymer, and this is then used as a mask to etch the pattern in metal. This technique allows the pattern to be reproduced quickly over large areas and Harwell aims to adapt it for perovskite cells.

"Making possible the easy production of back contact PSCs could help make PSCs with higher efficiency than the sandwich structure, while reducing material costs and removing design constraints," he said.

AIRBUS BATTERY BOOST FOR ZEPHYR

Airbus Defence and Space has invested in US-based battery technology company Amprius, to boost the development of new generation batteries based on silicon nanowire anode technology.

The investment will help drive the development of higher volume production capacity, and cells with higher energy density for programmes such as the Zephyr high altitude pseudo satellite (HAPS) and Urban Air Mobility innovation initiatives.

Amprius was the first company to introduce 100 per cent silicon anodes in lithium ion batteries in 2013. It manufactures the highest energy density commercial batteries in the industry. The company's products and technology include a 100 per cent silicon nanowire anode, silicon-graphite composite anodes, lithium-rich cathodes, and high voltage electrolytes tailored for silicon.

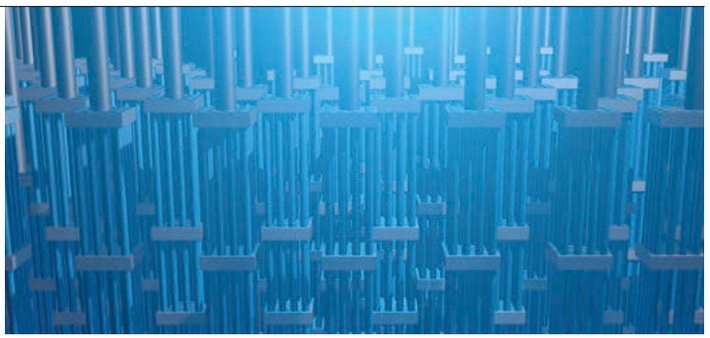
One Airbus application will be with Zephyr, the solar-electric, stratospheric unmanned aerial vehicle that combines some of the attributes of an aircraft and some of those of a satellite, with the ability to stay focused on a specific area of interest while providing satellite-like communications and 'persistent surveillance'. This would give the ability to monitor the spread of wildfires or oil spills, for example. It operates at an average altitude of 21km, has a wingspan of 25m and weighs less than 75kg. On its maiden flight, the first production model of the aircraft flew for over 25 days.

"This partnership reinforces the link between two market leaders, the newest generation batteries on the market matched with the most advanced HAPS programme," said Jana Rosenmann, head of Airbus Unmanned Aerial Systems. ***DF***

Liquid metal testing facility could boost fast reactors

Anglo-American project looks to smaller nuclear reactors

DAVID FOWLER REPORTS



Manchester University is the UK partner in a three-year joint US/UK project to develop a liquid metal testing facility that will help investigate the behaviour of liquid lead as a coolant for nuclear fast reactors.

Liquid metal cooled reactors have been investigated for marine propulsion, but not for power generation, and have not been produced commercially.

Their advantages are the excellent heat transfer properties of liquid metals, which allows the reactor core to be more compact. Liquid metals can be heated to temperatures of hundreds of degrees Celsius without the need for pressurisation as in a water reactor, which makes them safer to operate. The higher operating temperature boosts the overall thermodynamic efficiency of the plant.

Dr Andrea Cioncolini, associate professor of thermal hydraulics in the university's Mechanical, Aerospace and Civil Engineering department, said liquid metal cooled reactors would be smaller and simpler to make, so many small reactors could be built instead of large bespoke units. Small modular reactors could have long-life prefabricated cores that could run for several years before being replaced.

However, little is known about the behaviour of liquid lead and in particular the erosion and corrosion of materials exposed to it at high temperatures. Investigation is made more difficult by the fact that lead is opaque.

The test set up will consist of an approximately 15L cylindrical vessel, which will have test samples arranged around the wall. It will be filled with liquid lead and a variable speed impeller in the centre will generate a flow of metal at up to 700°C, causing erosion.

Corrosion products could build up on the samples, or in stronger flows they could be removed and deposited elsewhere. "Ideally you want to produce as little corrosion as possible, and then you want to know where it will be deposited," Cioncolini said.

EPSRC is funding the UK's involvement and Manchester's role will be to undertake computational fluid dynamics (CFD) simulations, first to inform the design of the apparatus and then to help interpret and analyse the results. Overall, the project is expected to push the boundaries of knowledge of the behaviour of liquid metals.

AI RAIL INSPECTION MAY SAVE £10M

Annual savings of £10m could be realised following the joint development of railway track inspection software by Omnicom Balfour Beatty and York University.

After two-and-a-half years in a Knowledge Transfer Partnership a machine-learning technology has been developed to digitalise and advance the way railway line inspections are carried out.

In use, inspections are carried out by a camera attached to the front of a train, which captures high-definition images of the rail track to generate data that is analysed for inaccuracies and faults on the tracks. In addition, the technology assists in identifying where faults may occur.

"These machine vision technologies for high speed rail inspection will improve the reliability of the railway network, reduce costs and increase the safety of manual inspection," said Prof Richard Wilson, lead researcher on the project from York University.

The automated technology is now being taken from proof-of-concept into a commercial grade software that will minimise human exposure to live track environments. ***JF***

Read more at www.theengineer.co.uk

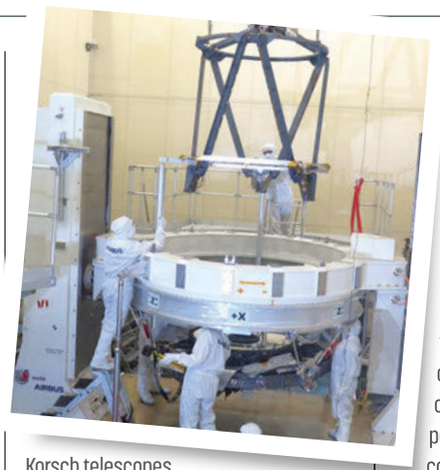
EUCLID TELESCOPE AT FINAL STAGES

STUART NATHAN REPORTS

Assembly is now underway on the main telescope of Euclid, the highest-performance optical instrument that Airbus has ever constructed.

The Euclid mission aims to map the geometry of the "dark universe" - the regions which are too cold to emit visible light. "With the ultimate goal to understand the origin of the Universe's accelerating expansion, Euclid will map the geometry of the dark universe with unprecedented accuracy," said mission project manager Giuseppe Racca. The spacecraft, operating at temperatures of 100K, will collect a different high-resolution image every 80 minutes for six years.

The module being constructed in Toulouse has three primary features: the main telescope, a 1.2m diameter mirror and a three-mirror Korsch telescope, a type of instrument designed to be free from the optical aberrations incurred by telescopes with only one mirror.



Korsch telescopes are capable of a wider field of view than single-mirror types and on Euclid will supply light to two scientific instruments that will analyse the wavelengths and provide information about the composition of the objects it is observing.

The Toulouse team is currently assembling the main telescope. After mounting the truss onto the base plate - both components being made of silicon carbide - Airbus engineers are now performing optical alignment. Once complete, the module will be sent to Thales Alenia Space in Italy for further testing and integration.

Blowing bubbles for storage

Energy storage material takes shape in Nottingham

DAVID FOWLER REPORTS

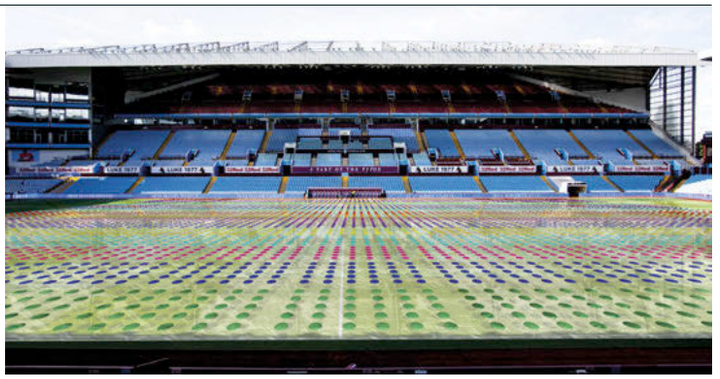
A new thermal energy storage material dubbed ChainStore has potential applications from heating and cooling of buildings and greenhouses to thawing frozen football pitches.

The technology, which uses biodegradable materials and can be made in large quantities, was developed by a team led by Professor Saffa Riffat, President of the World Society of Sustainable Energy Technologies and head of Nottingham University's Buildings, Energy and Environment Research Group, working with research fellow Professor Yijun Yuan.

With the world's requirement for electrical power growing rapidly, and because of the intermittent nature of most renewable energy sources, the need for efficient energy storage technology is increasingly urgent.

Thermal energy storage (TES) technology allows energy to be stored by heating or cooling a medium such as water, or causing a phase change in a material such as wax. The energy can then be recovered at a later time.

Prof Riffat said most TES technologies are expensive and have poor heat transfer capabilities – it is not easy to get the heat in or out of the storage medium.



ChainStore uses a low-cost biopolymer material which is biodegradable. The material can be formed into bubbles to contain the energy storage medium. "It can be made very quickly in long chains or to cover large areas, at low cost," said Prof Riffat.

The energy storage medium is a composite crystalline material, but details are not currently being released as its going through the patent process. Prof Riffat said, however, that it has very high energy storage capacity compared with water.

Applications are expected to include cold storage, where the store, including the ChainStore material, would be cooled when renewable or cheap-rate electricity was available. At times of peak electricity rates or when renewable energy was not available, the material would absorb heat and keep the store cool.

Installed on ceilings in buildings it would absorb heat and reduce the need for air-conditioning during the day, and release heat at night. For sports pitches an "active" version of the product, with electric heating elements built in, would be pre-warmed, then unrolled over the pitch.

UKRI MATCH-FUNDS NUCLEAR DESIGN

UK Research and Innovation is to provide an initial £18m in match funding to a consortium of companies working on the preliminary design for a standardised small modular reactor.

The power station is a compact design with components manufactured in sections before being transported to existing nuclear sites for assembly inside a weatherproof canopy, which cuts costs associated with weather disruptions. This method is also expected to lead to savings by using streamlined and standardised manufacturing processes for its components.

According to consortium lead Rolls-Royce, a fleet of 16 small modular reactors in place by 2050 could create 40,000 jobs, add £52bn to the UK economy, and have an export value of £250bn. ***JF***

Read more at www.theengineer.co.uk

GETTING SMARTER IN THE HARBOUR

DAVID FOWLER REPORTS

Wärtsilä and Singapore-based marine services provider PSA Marine are to collaborate on the development of smart technologies for the marine sector.

Areas of expected collaboration include electric or hybrid technologies to increase the use of low-emission energy and propulsion systems; the incorporation of next-generation smart vessel technologies; the adoption of secure connectivity to allow ship-to-shore data exchange; plus marketing and branding activities.

PSA Marine and Wärtsilä have pledged to design and develop more solutions for smart and low-emission harbour craft. The intention is to integrate the capabilities developed in the IntelliTug project, which is bringing an autonomously operated harbour tug concept to feasibility, with hybrid, electric, and other clean energy sources.

IntelliTug technologies undergoing testing aboard PSA Marine's PSA Polaris tug include the joystick and digital control of the vessel's azimuth thrusters, virtual anchoring to hold position, smart navigation with automatic path planning, and situational awareness for detecting and avoiding the risk of collisions.

The Wärtsilä Acceleration Centre has played an important role in the project, which also led to the launch of Wärtsilä's Smart Technology Lab in Singapore. The lab provides facilities for testing integrated technologies in close cooperation with customers and users in a collaborative environment.

"We look forward to continuing our innovative and important work together," said Wärtsilä Singapore managing director Mervin Ong.

"PSA Marine and Wärtsilä intend to lead and develop smart, scalable, and clean energy solutions, as we play our part towards decarbonisation and the reduction of greenhouse gas emissions," said PSA Marine's Peter Chew.

MERGER CREATES AUTOMOTIVE GIANT

Fiat Chrysler and Peugeot are entering a merger that will create the world's fourth largest automotive manufacturer with combined revenues of nearly €170bn.

According to a joint statement, the decision to merge has been brought about by the shared conviction 'that there is compelling logic for a bold and decisive move that would create an industry leader with the scale, capabilities and resources to capture successfully the opportunities and manage effectively the challenges of the new era in mobility.'

The merger is expected to lead to annual savings of approximately €3.7bn that will be brought about in part by spreading the cost of large-scale investments in vehicle platforms, powertrain and technology. Consequently, neither company anticipates any plant closures.

Peugeot boss Carlos Tavares will assume the role of CEO for an initial term of five-years. "This convergence brings significant value to all the stakeholders and opens a bright future for the combined entity," he said. **JF**

Read more at https://www.theengineer.co.uk

Armoured vehicle contract to safeguard British jobs

Contract calls for over 500 UK-built armoured vehicles

JASON FORD REPORTS

A contract valued at around £2.3bn to build armoured vehicles for the British Army is expected to safeguard and create a substantial number of British jobs.

The Artec consortium, led by Rheinmetall and Krauss-Maffei Wegmann (KMW), signed the contract with the Ministry of Defence to produce over 500 Boxer 8x8-wheeled vehicles in configurations including armoured personnel carrier, command vehicle, specialist carrier and field ambulance.

Delivery of the vehicles, which are part of the UK's Mechanised Infantry Vehicle (MIV) procurement programme, will likely start from 2023.

The total number of Boxer vehicles delivered by Artec or on order now exceeds 1,400 units. In a statement, Artec said that 90 per cent of the Boxer vehicles destined for the British Army will be produced in the UK, primarily at plants operated by Rheinmetall BAE Systems Land (RBSL) and KMW's subsidiary WFEL.

Commenting on the deal, defence secretary, Ben Wallace, said: "The vehicles will form part of the Army's Strike brigades, new units set up to deploy rapidly over long distances across varied terrains.

"Boxer is modular by design to meet these requirements - the same vehicle base can be rapidly reconfigured to fill different roles on the battlefield, from carrying troops across deserts to treating severely injured service personnel on the journey to hospital.

"Initially the army will buy a mixture of the troop-carrying variant, ambulances, command vehicles, and specialist designs to carry military equipment."

There are currently 700 Boxer vehicles in 12 different versions on order from Germany, the Netherlands and Lithuania. Australia has ordered 211 Boxer Combat Reconnaissance Vehicles (CRV) in seven variants, the first of which was recently delivered.

The new order marks the return of the UK to a European defence programme, having taken part in the Boxer project when it was still in its infancy.

Bombardier sells Belfast plant in $1bn deal

Bombardier is selling its Belfast manufacturing facility to Spirit AeroSystems as part of a deal valued at over $1bn.

Along with Short Brothers in Belfast, Spirit AeroSystems is also taking ownership of Bombardier's operations in Casablanca, Morocco and a maintenance facility in Dallas, USA for $500m.

The Wichita, Kansas headquartered company said it would assume approximately $300m in pension liabilities, and approximately $290m of government grant repayments.

At closing, Spirit AeroSystems will pay $500m to Bombardier and make a cash contribution of approximately $130m towards the pension liability, for total cash at closing of $630m.

The acquired operations employ over 4,000 people across the three sites, the majority of which are in Belfast. The backlog of work includes long-term contracts on the Airbus A220 and A320neo, along with Bombardier business and regional jets.

In aerostructures and fabrication, the acquired business produces composite and metallic wing components, nacelles, fuselages and tail assemblies, along with high-value mechanical assemblies made from aluminium, titanium and steel. The acquired business also brings an aftermarket business that more than doubles Spirit's global reach.

The expected revenues of the Bombardier operations will be approximately $1bn in 2019 and the transaction is expected to close in the first half of 2020.

Commenting on the deal, ADS chief executive Paul Everitt said: "Spirit AeroSystems is one of the largest aerostructures businesses in the world, and this deal sees them significantly expand their operations in the UK, while also opening up new opportunities for the Belfast facility to grow its business with the US and elsewhere." **JF**

Read more at https://www.theengineer.co.uk/aerospace

Innovation continent

A new generation of African engineering entrepreneurs are turning problems into opportunities

WRITTEN BY JASON FORD

A significant disparity exists in continental Africa where the number of young people entering the labour market outnumber the positions available by up to four-to-one.

According to the UN Economic Commission for Africa, around 10–12 million young people enter the workforce per year on a continent that creates approximately three million formal jobs. The same organisation estimates that one third of African youths aged 15–35 are unemployed, and another third are described as 'vulnerably employed'. Women face higher unemployment and underemployment than men and face greater obstacles to job opportunities and equal pay.

Significantly, the number of African youths is predicted to double to over 830 million by 2050, an apparent demographic timebomb that could be defused by cross-continental government initiatives designed to support young entrepreneurs, many of whom are applying engineering solutions to everyday problems.

Among them is Nigerian Aisha Raheem who has developed Farmz2U, a digital platform that prevents food waste by helping farmers plan their crops. She told The Engineer via email that there has been an increase in policies and government sponsored programs to encourage the activities of micro, small and medium enterprises (MSME), and start-ups in her country. Some of these include the Central Bank of Nigeria's MSME Development Fund launched in 2013 and the Skills Acquisition and Entrepreneurship Department (SAED), which supports graduates with loans, training and apprenticeship programs.

In Ghana, the National Entrepreneurship and Innovation Plan has been recently set up and is offering training and seed capital to young entrepreneurs. Tax incentives exist too for entrepreneurs working in certain fields. In Uganda, a National ICT Initiative Support Programme (NIISP) provides an ecosystem to encourage start-ups.

Adrian Padt is a South African who has developed DryMac, a containerised drying system that uses burning biomass instead of electricity to dry and preserve crops. He said that various seed-funding opportunities exist in South Africa, with the Department of Trade & Industry and Trade & Investment KwaZulu-Natal able to provide start-up funding. Furthermore, the Industrial Development Corporation provides business finance at preferential rates for qualifying start-ups.

The 2019 African Economic Conference concluded that regional success stories should be replicated across the continent with multiple stakeholders exchanging ideas and sharing best practices. Conference partner the United Nations Development Programme (UNDP) is particularly keen to see entrepreneurship contribute to emerging and developing economies, and cites an OECD study from 2015 which found that out of 18 countries sampled over a 10 year period, SMEs employed up to 65 per cent of the workforce and accounted for up to 75 per cent total gross job creation in Europe.

If properly harnessed, said UNDP, then 'Africa's youth bulge has the potential to translate into a dividend for the continent through the creation of enterprises that not only contribute towards economic growth, but also create jobs for their fellow youth.'

> "AFRICANS ARE MORE UPBEAT ABOUT THEIR ABILITY TO CREATE THEIR OWN BUSINESSES"

This sentiment is echoed by Kenyan Tracy Kimathi, who has developed a solar system that powers communal refrigeration storage spaces in rural Kenya.

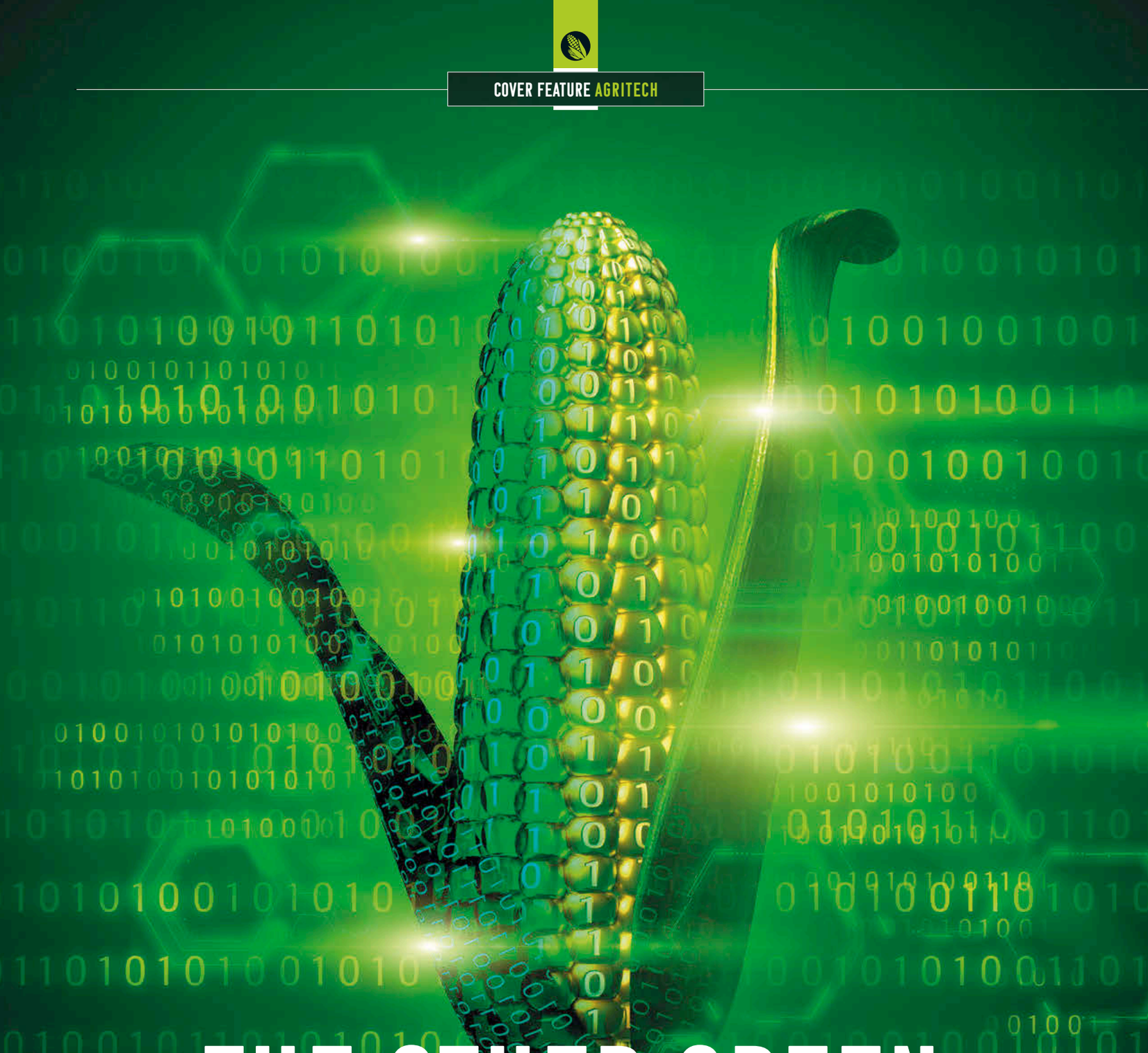
"Lack of employment opportunities in large cooperates have stirred up the opportunistic ventures of African entrepreneurs in a bid to not only create jobs for themselves but the majority youths that still face unemployment," she said via email.

For Ghanaian Bernice Dapaah, Africa's demographic shift is a clear driver of change, but she added 'the drive toward entrepreneurship is due to the fact that more and more young Africans are now more upbeat about their ability to create and manage businesses than any time in history.'

Dapaah founded EcoRide, a company that makes bamboo bicycles and, in common with Padt and Raheem, is one of the shortlisted entrants to the Royal Academy of Engineering's Africa Prize for Engineering Innovation 2020.

The prize was launched in 2014 and competition alumni are forecast to impact over three million lives in the next five years, having already created over 1,500 jobs and raised over $14m in grants and equity.

"Foreign support is very important in helping us develop a global outlook and build a stronger foundation," Dapaah said. "I see the Africa Prize as a great opportunity to use its huge intellectual asset to our benefit in growing our business and refining our process engineering." THE ENGINEER



THE OTHER GREEN REVOLUTION

AI-enabled robots, crop spraying drones and smart machine vision systems are just some of the technologies driving what some are calling the fourth agricultural revolution. Andrew Wade reports

At the inaugural Future Farming Technology event, held recently in Birmingham's NEC, the primary message was loud and clear: agriculture in its current state is broken. Practices largely unchanged since the 1960s have seen arable farming in particular stagnate and yields across the globe plateau. Farmers paint a picture of an industry over reliant on chemicals and gigantic machinery that's squeezing the life out of once-rich soils. But a wave of new technology is helping the sector reverse the decline.

"We're part of a global trend in how farming is changing," said Sam Watson-Jones, co-founder of UK agritech startup, Small Robot Company (SRC). "We think that arable farming in its current form doesn't work."

As a fourth-generation Shropshire farmer, Watson-Jones is speaking from experience. He says yields have remained static for more than a quarter of a century, despite the UK using over a million tonnes of herbicides and fungicides each year.

"The third agricultural revolution is what we're living through today," he said. "It's defined by chemicals, it's defined by fertiliser, it's defined by big, heavy tractors. But it's no longer working for farmers and we need something new to take us into the future.

"The fourth agricultural revolution, by contrast, can be defined by swarms of small, smart machines and minimal, or no, cultivation at all."

The huge tractors, sprayers and harvesters deployed on farms around the world are compacting soils and depleting nutrients, pushing farmers into a feedback loop where they're forced to use ever more intensive methods. Downsizing the machinery not only protects the soil, it allows farmers to cultivate on a much more granular scale, attending to individual plants in what's known as precision farming.

"We're moving away from thinking about our fields, to gathering data and taking action on the individual plant – every single plant in your field," said Watson-Jones.

It's a concept that's been championed for over a decade by Professor Simon Blackmore of Harper Adams University im Shropshire, and one that inspired Watson-Jones and co-founder Ben Scott-Robinson to launch Small Robot Company in 2017. Their robots Tom, Dick and Harry respectively look after field monitoring, weeding/cultivation, and planting.

Of the three, Tom is at the most advanced stage of development, due to enter commercial service this growing season. Its latest iteration was launched at Future Farming Technology, boasting a double camera system that increases monitoring capacity to four metres squared. According to SRC, Tom can cover around 20 hectares per day, feeding individual plant data back to an artificial intelligence system known as Wilma, which helps farmers interpret the information.

Small Robot Company's Tom robot and (below) SRC co-founder Sam Watson-Jones

"The robots are automating things, but Wilma is the brains behind the operation," explained Watson-Jones. "She's the bit that is really going to cause the shift to a new way of farming."

Alongside the revamped Tom, SRC also unveiled a commercial service for weed mapping, a world-first according to the company. Heat maps of broadleaved weeds will allow farmers to spray more effectively as well as shape future planting decisions. Further down the line, it's envisaged that Dick will both feed and weed autonomously, micro-spraying based on data and analysis from Tom and Wilma. Harry, the planting robot, is still at the prototype stage. All three will operate under a service package where the company will charge by the hectare to manage plots of land, avoiding the need for farmers to make large up-front investments.

SRC is also working with a Warwickshire-based firm called Rootwave that uses an electrically charged metal arm to boil weeds from the inside, killing them from the root up. It's all part of a plan to transition from mass application of chemicals to highly targeted use, and perhaps one day no chemicals at all.

"Reducing inputs is really important," said Jamie Butler, a dairy and arable farmer who has taken part in trials with SRC. "Obviously, for farming economics, but also it is absolutely the way forward for the environment, for soil health and management...I'd say that 90 per cent of the chemicals and fertilisers that we're putting on (our fields) probably aren't necessary and could be significantly reduced with the right technology."

Butler echoes Watson-Jones's sentiments on farming's wider problems. Despite being an early adopter of technology, he has had to diversify the Hampshire farm he runs with his brother, offering glamping, self-storage and corporate fly-fishing to supplement the traditional income from crops and livestock.

"In some respects, I think the outputs →

Illustration credit: Oliver Burston

on farms are – maybe not as high as they can go, they could go higher – but I'm not convinced that farmers would see the profit in that," he explained.

"We'd just be supplying an oversupplied market. Why do we need to produce more? Actually, what we need to do is produce more efficiently."

UK markets may currently be oversupplied, with big retailers squeezing farmers' margins to the limit, but tomorrow's food security is more fragile. It's estimated that the global population will hit 10 billion by 2050 – around 2.5 billion more mouths to feed than today. If chemical-heavy farming and monster machinery persists, soils could eventually be pushed past the point of no return. Combined with the added threat that climate change poses to land use, the status quo simply has to shift.

"I think precision farming is going to be an absolute revolution, with autonomous vehicles and also with weed identification," said Butler.

"At the moment we're not there, but if people like Small Robot realise their dream, we will be there."

SRC is by no means the only UK outfit championing technology as a solution to agriculture's problems. Since October 2016, Harper Adams University - to where many of Small Robot's ideas can be traced - has been running a research project on autonomous farming, using small, retrofitted tractors and harvesters alongside drones and AI.

Known as the Hands Free Hectare, the project produced its first crop of spring barley in September 2017, with six tonnes of winter wheat following a year later. In May 2019 the project was extended for another three years, scaling from a single 'perfect' hectare to 35 hectares across five different fields, and relabelled as the Hands Free Farm.

"They're fields that have not had any adjustments from standard agriculture," Jonathan Gill, a mechatronics engineer at Harper Adams and one of the project leaders, told *The Engineer*.

"We've got five fields, all of which have got non-straight headlands. The most challenging...has got telegraph poles, it's got a public right of way through the centre of it, it's undulating, it's got four different soil types."

Whereas SRC has purpose-built robots from scratch, the Harper Adams team has taken a different approach, customising existing, compact machinery with technology that allows it to farm autonomously. For the Hands Free Farm, a second Iseki tractor has been added to the fleet, alongside a Claas combine with a much smaller footprint than their previous harvester. Existing partner Precision Decisions is managing control systems and route planning, with new project member FarmScanAG adding autonomous capabilities.

"What we're really looking at is the smart implement level, the implements and the machinery that goes on to the vehicle," said Gill. "The new technology of grow systems, the new technology of bailing, and everything in between."

According to Gill, the leap from a single, fenced hectare to a messy 35 hectares will really put the technology through its paces. For the original hectare, the team set themselves the challenge of planting, tending and harvesting with absolutely no human presence allowed in the field. The Hands Free Farm will take a more practical approach, agronomists and students working in tandem with the autonomous machinery, taking soil samples manually and making some decisions the old-fashioned way.

Cambridge Consultants' Fafaza system can identify and spot-spray weeds in a single pass at tractor speed

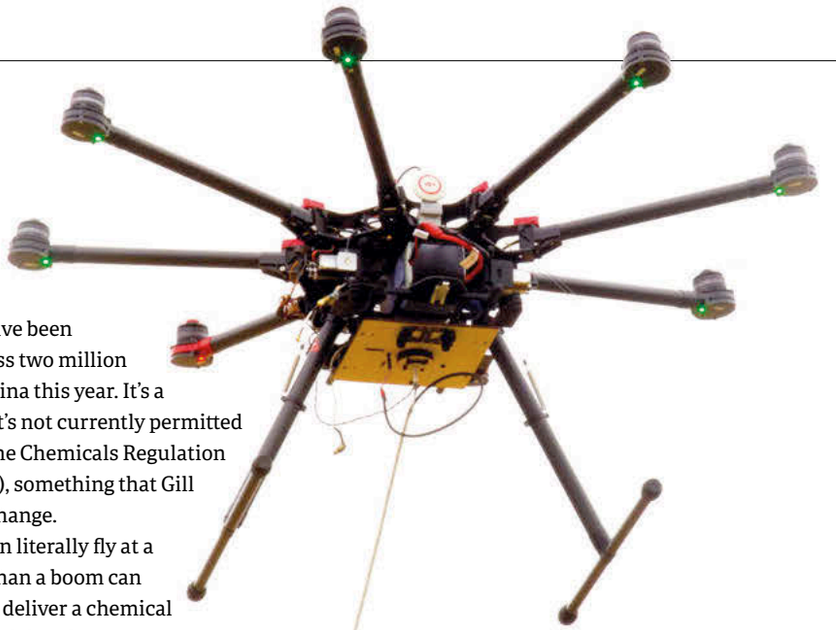
Mike Gutteridge, Jonathan Gill and Kit Franklin of Harper Adams University and the Hands Free Farm

"I'd never really want to stop a farmer or agronomist going on the land and actually making decisions, so we're not going to do that," said Gill. "What we'd like to do is provide additional tools to help them do it.

"It's got a lot more sensible, it's got a lot more professionalism behind the entire project to actually try and operate something on a routine basis instead of it just being like a feasibility study. This is not about the feasibility anymore, it's more about the proof of capability of autonomous farming."

Part of that proof will involve drawing up a realistic picture of the economics and seeing where autonomy can potentially generate savings. Data from all vehicles in relation to run times, distance and fuel consumption will be collated and crunched. For crop data, new partner Pix4dFields has come on board to provide a drone system that will capture regular updates from above the fields.

Gill, a drone specialist himself, believes UAVs will play a crucial role in the coming agricultural revolution, and not just for monitoring. He points to the example of XAG, a Chinese manufacturer



of precision spraying drones that have been deployed across two million hectares in China this year. It's a technique that's not currently permitted in the UK by the Chemicals Regulation Division (CRD), something that Gill thinks must change.

"A drone can literally fly at a lower height than a boom can operate at and deliver a chemical at a higher precision than most standard sprayers," he explained. "A spray drone doesn't have the same precision as a single nozzle-controlled sprayer, but it's that middle ground in between, and the price of the technology is so much cheaper and it doesn't cause any compaction."

Drone spraying also opens up the possibility of cultivation when ground is saturated and farmers can't get a traditional sprayer into the field.

"There are perfect capabilities for these drones to actually operate and work within those environments," said Gill, "but we're being prohibited by our regulation system preventing us actually operating these vehicles."

Drones are ideal for monitoring broad acre crops like wheat and corn, but keeping track of individual fruits and vegetables requires technology in the trenches. Mamut, developed by engineers at Cambridge Consultants, is a compact four-wheeled robot that travels through fields collecting and analysing data. Using stereo cameras, LIDAR, an inertial measurement unit, a compass, wheel odometers and onboard AI, it can navigate new environments autonomously, providing a real-time picture of crop-health at ground level.

"Fruits and vegetables – in particular citrus fruits – you can't see what's happening from above because it's covered by the canopy," explained Niall Mottram, head of Agritech at Cambridge Consultants. "And there aren't enough hours in the day for someone to walk up and down the rows of an orchard or a vineyard to count grapes or apples."

Central to Mamut's effectiveness is its ability to operate independent of GPS or radio infrastructure, as well as its machine vision and AI that analyses crop data without the need for external computation.

"That kind of AI on the edge, where you don't need to use lots of cloud compute platform power – because that's not practical in an agriculture environment, you don't have the real-time connectivity – that kind of approach is key if you're going to see that AI jump out of the data centre and into the field to deliver some benefit," said Mottram.

Mamut's role is limited to analysis, but Cambridge Consultants has taken the next logical step of edge computing and built a system that can act on the insights in real-time. Fafaza is a precision crop spraying technology that not only spots broadleaved weeds, but also accurately delivers herbicide on the same pass. This type of 'green on green' plant recognition is challenging, with computation previously outsourced to the cloud. Having the computing on the edge means a single system can detect the problem and deal with it instantly.

> **"I THINK PRECISION FARMING IS GOING TO BE AN ABSOLUTE REVOLUTION"**

What's more, Fafaza is built to work with off-the-shelf components such as a basic camera that captures 20 frames per second and an AI processor that costs less than £100. The system can be deployed on the back of a vehicle, identifying and spraying weeds at 'tractor speed'.

"If you're able to spot spray those weeds, there's an excellent economic benefit because you're using less herbicide, and there's obviously that massive environmental benefit at the same time, because you're not over spraying and getting run-off," said Mottram.

The benefits of precision farming – whether by smart implements or robots - could go far beyond minimising chemical inputs and have much wider implications, reshaping not just the way we cultivate crops, but physically reshaping the lay of the land itself.

SRC's weed spraying robot, Dick

"The countryside we have today is a complete product of the 3rd agricultural revolution," said SRC's Sam Watson-Jones. "It's big square fields where lots of hedges have been taken out.

"When you can get to a point where you can individually harvest a plant, why couldn't you have multiple commercial crops alongside each other? Why couldn't you have things that ripened at different times?"

Precision harvesting technology isn't quite there yet, but it could be the final piece of the puzzle, allowing the fundamentals of farming to be rewritten. Different crop varieties could be co-planted to combat disease or encourage pollination, changing the entire face of the agricultural landscape. According to Watson-Jones, it's a revolution that farming must embrace.

"It's about completely reimagining the way that we use our soil to produce food." THE ENGINEER

SOUTHERN 20 Manufacturing & Electronics

Incorporating The Subcontract Engineering Exhibition
AUTOAERO
FARNBOROUGH • 11-13 FEBRUARY 2020

FREE SEMINARS
FREE PARKING

FARNBOROUGH | Hants | GU14 6TQ

11th | 12th | 13th FEBRUARY 9.30am - 4.30pm *(3.30pm close Thurs)*

Where Industry and Innovation converge

Meet over 800 national and international suppliers at the Farnborough International Exhibition & Conference Centre this February at Southern Manufacturing & Electronics (inc AutoAero) 2020. See live demonstrations and new product launches of machine tools & tooling, electronics, factory & process automation, packaging & handling, labeling & marking, test & measurement, materials & adhesives, rapid prototyping, ICT, drives & controls and laboratory equipment.

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

The exhibition is **free** to attend, **free** to park and easy to get to. Doors open at 9.30am on Tuesday 11th February.

OIL & GAS
DEFENCE
FOOD & DRINK
AUTOSPORT
MARINE
AEROSPACE
PACKAGING
LOGISTICS
ELECTRONICS
AUTOMATION
ROBOTICS
MEDICAL
COMPOSITES
SPACE ENGINEERING
RAIL
TRANSPORTATION

▷ PRE-REGISTER TODAY
for your Fast Track Entry Badge, Preview Magazine and Event Catalogue at
www.industrysouth.co.uk

SOUTHERN MANUFACTURING & ELECTRONICS
is an ETES event organised by European Trade & Exhibition Services Ltd
Tel 01784 880890 · email philv@etes.co.uk

etes Regional Manufacturing Exhibitions

Supported by: fac · CBM Confederation of British Metalforming · Composites UK Trade Association · BGA British Gear Association · gtma · NetComposites

ANDRE LAPERRIERE

Agriculture requires a technology revolution

Andre Laperriere, Executive Director of Global Open Data for Agriculture & Nutrition (GODAN)

The interface of the agriculture sector is changing. Whilst farming remains one of the oldest and most important professions in the world, technology advances have gradually made their way into the practices of farmers, particularly in economically developed countries. Despite this, with the global population growing rapidly, the need for advanced artificial intelligence (AI) and technology across a more mass scale has never been more apparent.

Climate change is one of the biggest threats currently facing the world. With society experiencing more natural disasters and adverse weather conditions, there has been a constant fear for many industries as to whether they can maintain business and trade in the long-term. The agricultural industry is no exception, with the sector facing a crisis of significant magnitude due to climate change. In the US alone, natural disasters cost agriculture over $5 billion in 2017 . With more crops being destroyed as a result of poor weather conditions, the effects of global warming on our ecosystem are putting livelihoods and food security at risk. However, the role of the rural community will be pivotal in helping to turn this around. By driving innovation from top to bottom, the issues surrounding food security can be addressed and can help pave the way for creating sustainable practices and helping feed the 795 million currently starving in the world .

The central focus to modernisation and innovation should be the effective use of technology and data. Whilst this may be a break from longstanding 'traditional' methods of farming, now is the time to embrace a new proficiency in order to address the many issues facing agriculture, as well as evolving in tandem with the growing output demands of the agriculture industry. The use of technology and data not only hinges on its availability but also the training and education on using it effectively. In turn, this should spark greater innovation as farmers adapt and learn new ways to constantly better themselves and their crop production.

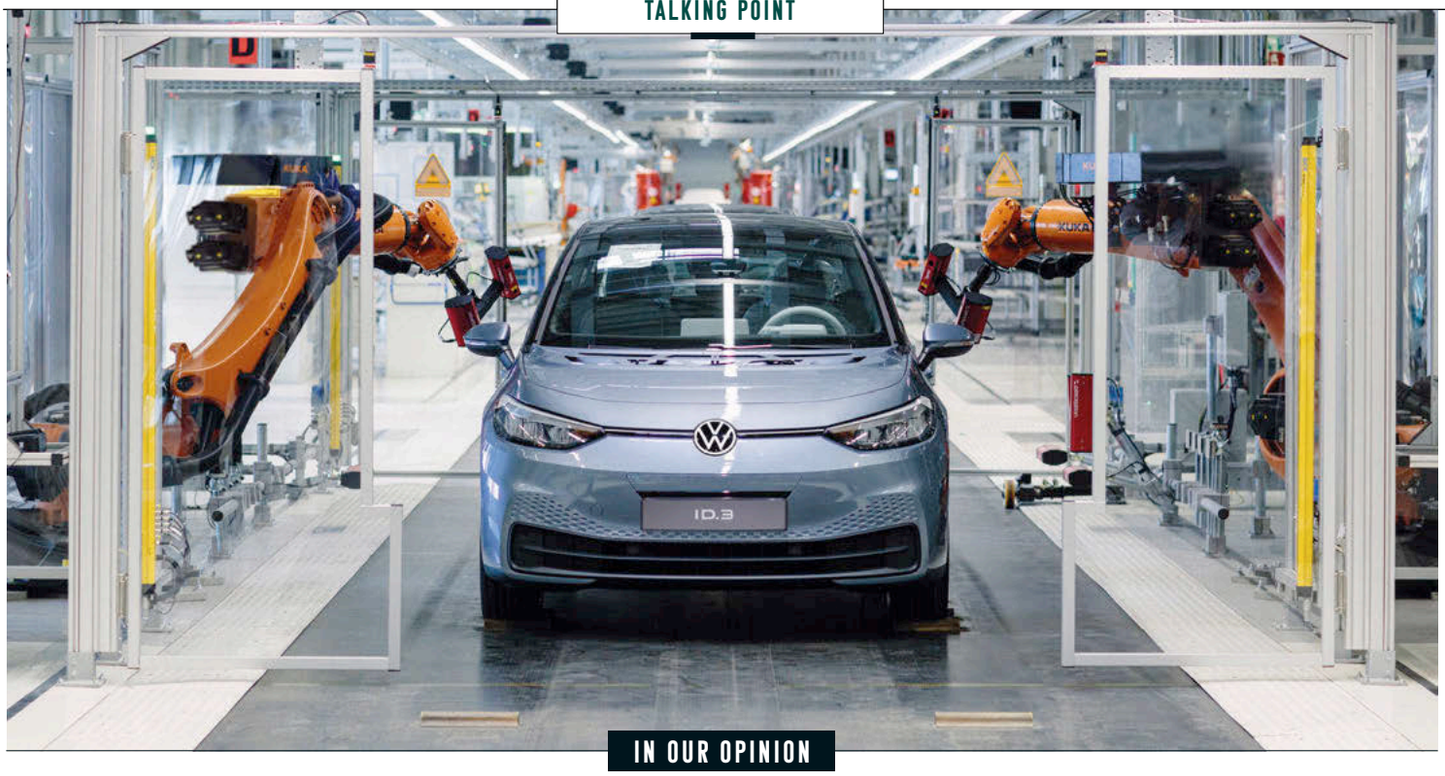
As the world population continues to grow and land becomes more scarce, people have needed to get creative and become more efficient about how they farm. The use of AI is increasingly becoming a necessity. AI holds the promise of driving an agricultural revolution at a time when the world must produce more food using fewer resources. AI innovations such as drones are already playing an important economic role as pollinators as the bee population continues to decline. Moreover, other examples of AI, such as driverless vehicles are allowing farmers to automate their existing equipment and maximise their efficiency and capacity.

Another key instigator for innovation can be by encouraging the use of open data across the industry. If governments and policymakers enable wider access to historical and usable data, farmers will be able to develop their own effective farming and production practices for the better, including practices in monitoring water supplies, anticipating changes in the weather and sharing crucial information that others can learn and apply. With the correct approach and implementation methods in place, open data can have a high economic and social return on investment for countries across the globe. Africa is arguably the continent which is reshaping the agricultural industry for the better as it looks to combat food insecurity and improve global nutrition. In Kenya, where 80 per cent of people have access to some form of farmable land, plots are often abandoned. This has changed recently due to open-source mobile phone apps which have helped small-scale farmers maximise their crop yield, resulting in a solid economic stream for them and their communities. Apps provide relevant information such as local knowledge relating to geo, weather and market data which farmers can leverage to take advantage of Kenya's rich and fertile soil to plant healthy crops and make more informed farming decisions.

There is a need for greater engagement and cooperation initiatives that focus on sharing resources to ensure farmers are prepared to deal with the effects of climate change. Innovation and information is the central driving force for helping to achieve a more prosperous future which is free of hunger and malnutrition and thriving communities. THE ENGINEER

> "THE CENTRAL FOCUS SHOULD BE THE EFFECTIVE USE OF TECHNOLOGY AND DATA"

Image credit: Adiruch na chiangmai/stock.adobe.com



IN OUR OPINION

Electric avenues

After years of hype are we finally approaching the electric vehicle tipping point asks Jon Excell?

Many of us will know someone who drives an electric vehicle, and some of us will have even taken the plunge ourselves into the world of fossil fuel free motoring.

There's little doubt that electric cars - or cars boasting some significant level of electrification - are hurtling into the mainstream, with major manufacturers and governments around the world now championing a technology that was still very much at the fringes just a decade ago.

Today, rarely a week goes by without one of the major OEMs making further strides into this electrified future. At the time of writing, Ford had just announced plans to introduce 14 electrified vehicles into Europe by the end of 2020 (including an all-electric version of the iconic Mustang) whilst ID.3, the first of VW's much anticipated series of electric vehicles, had just rolled off the production line.

And whilst the proportion of electric cars on the world's roads is still relatively low, a combination of improved range and reduction in cost is fuelling the expectation that we are heading towards a tipping point in terms of adoption.

Much of this is being driven by a growing political and industrial appetite to drive the technology forward. At the 2019 conservative party conference, UK Prime Minister Boris Johnson (again, at the time of writing) put electric vehicles at the heart of £1.5bn pledge to tackle climate change, whilst the Labour party has promised to end the sale of internal combustion engine powered cars by 2030 and plans to invest as much as £5bn in technology and battery manufacturing infrastructure. And many of our European neighbours are signing up to similar, if not more ambitious, plans for the future.

It's very easy to get carried away by the technology's apparently inexorable rise, although as the recent and much-publicised demise of Dyson's electric car plans demonstrated, it still faces a number of challenges. What's more, the infrastructure to support electrification - from public charging points to low carbon generating capacity - is still nowhere near the level that would be required to support a wholesale shift to electric mobility.

And whilst the car industry seems to be betting its future on electrification, public attitudes - particularly in the UK - are proving stubbornly resistant to change.

A major 2019 Transport Research laboratory study – the Consumers, Vehicles and Energy Integration (CVEI) project - which included 447 consumer trials, found that only one in four UK motorists would consider buying a fully electric car in the next five years, with concerns over range still to the fore. Meanwhile, research published In November 2019 by KPMG - based on a poll of 2000 motorists - pointed to widespread concern over the availability of charging (75 per cent of over 55s and almost 40 per cent of 18 – 34 year olds).

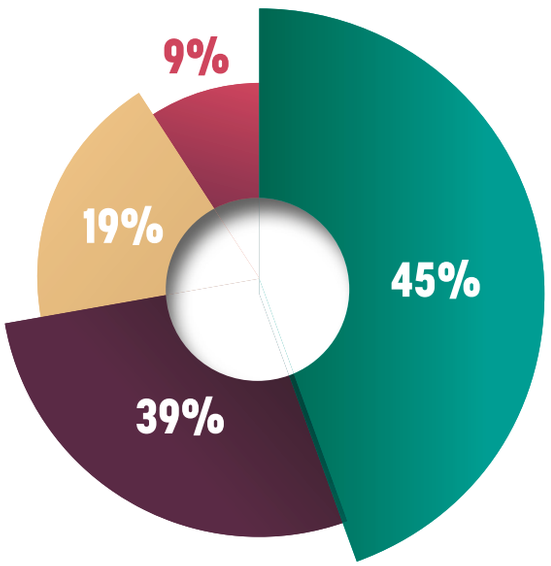
On the flip side, whilst we shouldn't dismiss these concerns, it's becoming increasingly apparent that many of the issues that concern consumers are rooted in misconceptions around the capabilities of the technology. With many electric vehicles now boasting an operating range of over 200 miles, range is perhaps not the issue that its perceived to be.

Perhaps the biggest challenge car makers face in getting consumers to buy into their vision is less about technology and more about winning the battle of hearts and minds and convincing a sceptical consumer base that not only will the electric car get them where they want to go, but also that it's here to stay. THE ENGINEER

Poll: Would you buy an electric car?

The Engineer's poll on the topic proved particularly emotive, attracting 1572 votes and generating a lively debate on our website.

Perhaps unsurprisingly, the largest single response group, 45 per cent, saw range and charging infrastructure as a major barrier to adoption. Meanwhile 19 per cent of respondents were unconvinced by the claimed environmental benefits of electric vehicles, citing concerns over both the raw materials for the batteries and the generating source for the electricity used to charge the vehicles. Over a quarter of voters were more positive about the technology and confident that it's mature enough for everyday use. Nine per cent of our sample group already own or drive electric vehicles.



Charging infrastructure and range concerns put me off

Yes, the technology is mature enough

I'm unconvinced by the claimed environmental benefits

I already own an electric car

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

SCAN ME

IN YOUR OPINION

As a 2nd car the current range is fine. But my main car needs to do 500+ miles in a day occasionally, and I don't intend to spend any of that in cafes waiting for it to charge. For that I would need huge range, or charging in a handful of minutes, or a green fuel hybrid. I suspect that an onboard green-fuelled generator to recharge will be the longer term solution that addresses the occasional high range that at least one car in my household is going to need.
Tim

My diesel car, chosen because we were told they were better for reducing CO2, will be replaced by a full battery electric car. Maybe a 2nd hand Tesla Model 3 when some become available or an ID.3.
Christopher Phillips

I Get the feeling that we are charging off in the wrong green direction with electric battery cars. Pure electric cars using batteries have many drawbacks, not least is range and recycling issues - hybrid may be a better and more practical use as an interim solution. The alternative green technology of hydrogen seems to be getting a back seat in all this, when it offers many of the benefits of electric-rechargeable cars and the ease and range of petrol/diesel cars.
Brian

The whole mad push to totally electric is misguided and being pushed through to appease the environmentalists. There are not enough rare earth materials (the clue is in the name!) to supply current battery design plus the negative effects of mining damage and their transport is being ignored. Also of course is the problem of electricity supply which if everybody took to electric cars would be woefully inadequate. A more sensible approach would have been to explore the hydrogen fuel cell approach and the infrastructure would be easier to put in place. Once again a panic response rather than a considered one to satisfy the loudest lobby group.
Geoff Calvert

I haven't seen one that I like with the room I need that I can afford. When one does become available, I may consider it, but price and residual value is still an issue. When I can get >50 mpg from my petrol Mazda , why do I need one? Who wants a used car with a dying battery? Battery leasing is essential.
Sandy

I have a second-hand, electric only, Nissan Leaf and I love it. It's perfect for my journey to work (40 miles round trip) and other short outings. I also have green electricity. I am infuriatingly smug. That said, my family couldn't manage without a larger, standard car, as it is quite impractical to use a small EV for long journeys or for towing etc. I'm not inclined to want to hang about for 30 minutes every 60 miles while the battery is recharged to 80% capacity. Then there's the potential arena of competition for charging stations - imagine your fury if someone has parked their car for longer than needed to recharge it, while you wait to access the charger!
Brian

Price, Range, Charging Time, Charging Infrastructure: too many negatives to interest me. I'm also concerned by the environmental negatives: the batteries and where does the electricity needed actually come from. The headlong rush towards EVs hasn't really been thought through. It's too easy for all the political parties and the technically challenged to set arbitrary and potentially unachievable milestones but the big questions aren't being addressed. What about infrastructure, baseline generation capacity, commercial vehicles, trains, ships, airplanes, the Military ? It's all hot air and politics until serious thought is given and real planning is done
Another Steve

Would I buy one? Yes
Will I buy one? No, not until the price comes down considerably. I am aware that running costs are a lot less, both in fuel and servicing, but in terms of overall cost I don't believe it would be good value. I have only ever bought used vehicles (no newer than 6 years old) and I can't see electric car second hand prices being competitive with equivalent ICE cars any time soon when purchase price and replacement battery costs are factored in.
I suspect if I did have one it would satisfy 90-95% of my journey needs, but I would not be able to rely on it as my only vehicle.
Gary Williams

The hot topic

The Bloodhound effect

The Bloodhound LSR team has conducted successful high-speed testing in South Africa, but what are the benefits of the project?

I use the Bloodhound Project in my design clubs and STEM talks at my local primary school. We have had a good turnout for design club whereby we discuss many aspects of the project including materials, aerodynamics, structures and dynamics. The children really engaged with this Project and we can align it with the key stage 2 curriculum. As a mechanical engineer it's very satisfying to see this level of interest from Years 4 – 6. Well done Bloodhound LSR team and thank you.
Michael Hatt

I think the world looks on when projects of this ilk are progressed. In the past Britain has been a world leader in engineering and ultimately the final speed of the car will be of interest but it is the 'spin off' in the interest it will engender to our young engineers of the future that will be of most benefit. The technicalities encountered by every discipline involved must be mind blowing and if that does not attract people into engineering, I don't know what would.
David Anderson

1000mph, then what ? Or rather, so what?
A jet engine mounted on a go kart, is that really innovation ?
If this is all that STEM ambassadors can come up with to sell engineering then we are doomed, and at the risk of being called sexist, I don't believe this sort of thing appeals so much to females. Engineering is so much more than this, these sort of projects have had their day, time to move on !
Another Steve

I think it's a fantastic project, it showcases many of the disciplines within engineering as well as the cross dependencies. Bloodhound is a great project that STEM ambassadors can use to illustrate whatever their area of expertise is. I'm a railway signalling engineer and I use it as an example of the cross disciplinary nature of many large engineering projects. Teamwork and communication are essential attributes for engineers. I find this aspect often appeals to girls in my audiences. That said, girls are also excited by a rocket on wheels.
Melanie Osborne

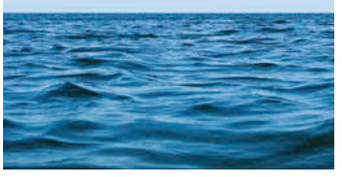
Bloodhound is so much more than a go kart with a jet engine and the full build details were available on the old website...the whole point is, it's an 'open' project allowing all to understand what's involved.
Martin

The Institution of Mechanical Engineers (IMechE) has urged governments to plan for a three metre sea level rise

I have long wanted to see Severn & Wash barriers. Coastal protection & clean power in one. Expensive, but cheaper than bailing out the banks. Perhaps a sweepstake on rising sea levels? If they predict three metres, then my guess is that it will end up much less than that. Perhaps half a metre. It would be interesting to still be around in 2099 and see who was right.
John Hartley

The IMechE report should be adopted immediately, at local and regional government levels, where computer model predictions are actualized in real time and where the best adapted solutions can be designed, built, implemented, including non-engineered solutions, like restoring the non-human natural habitat by abandoning or restricting the human habitat along the coastal areas
Silvia Leahu-Aluas

There is NO hype from climate scientists and the contrarian's 'science' is generally unsound. AGW is NOT temporary. It may become permanent, if we fail to quickly (in a decade or two) reduce the emissions that are responsible.
David Smart



Sozh/stock.adobe.com

ACCESS ALL AREAS

CMR Surgical's Versius robot is poised to bring the benefits of keyhole surgery to the masses.

JON EXCELL REPORTS

Since entering the medical mainstream over forty years ago, laparoscopic (or keyhole) surgery - which enables surgeons to access a patient's abdomen and pelvis without having to make large incisions - has had a profound impact on clinical care: reducing pain, boosting recovery times and lowering the risk of infection.

And yet, of the estimated 12 million pelvic and abdomen procedures carried out every year, only around fifty per cent are actually performed using minimally invasive techniques.

There are a number of reasons for this. Not least the fact that operating inside a patient's body with just a grainy 2D image to guide you is exceptionally difficult.

What's more, whilst there are some technologies available that simplify the process - such as the da Vinci robot, launched almost twenty years ago by US firm Intuitive Surgical - the high cost of these systems and the specialist facilities they require has limited their uptake.

ON DEMAND
Portable, lightweight and occupying a relatively small footprint when compared to other systems, the Versius robot has been designed with the NHS in mind and can easily be wheeled into an operating theatre as and when required

However, Cambridge-based medical technology start-up, CMR Surgical, is on a mission to change this and bring laparoscopic surgery to the masses with a surgical robot that's portable, cost-effective, simple to use, and - its developers claim - coming to an NHS hospital near you soon.

Developed from scratch in just five years, the company's technology, named Versius, is a modular system of robot arms that can be wheeled into an operating theatre and used to perform a range of minimally invasive procedures. A typical installation will see three or more robots used, with one arm holding an imaging probe and the others equipped with tools such as scalpels, graspers and suturing instruments.

During use, the robot is operated from a console in the corner of the theatre – linked via a 1-gigabit ethernet cable - where the surgeon uses gaming style controllers and a 3D display screen to perform the procedure.

As The Engineer discovered during a recent demonstration, the technology has immediate and compelling advantages over traditional techniques, where hand-eye coordination is exceptionally tricky and instrument movements are counterintuitive (i.e. to move the tip of an instrument to the left, the surgeon has to move their hand to the right). As well as providing

a 3D view, Versius cancels out these counterintuitive aspects, enabling the surgeon – or in this case the surgically inept journalist – to comfortably move the tools around without having to override the brain's instinctive commands.

To achieve all of this has required some exceptionally clever software, hardware, and electronics engineering, but as the firm's head of clinical engineering Fiona Haig explained, the underpinning innovation for the system is actually an elegant bit of mechanical engineering: the robot's wrist.

"The secret sauce really lies in the wrist of," she said. "It means that the robot holds the arm end-on, more like a surgeon would hold the instrument. If you look at traditional surgical or industrial robots they hold the instrument like a dagger."

The performance of this human-like wrist has, she added, been key to delivering a system that is compact and portable enough to fit into an existing operating theatre. Each arm is roughly one and a half times the size of a human arm and has a footprint of 38cm by 38cm. The system also draws on some of the collaborative robot (or co-bot) developments seen in other sectors.

"The advent of collaborative robotics has enabled us at CMR to leapfrog the incumbents," said Haig, "we're using the very best in the cutting edge in robotic tech and applying it to the medical field." Just as production engineers are able to work alongside co-bots on the factory floor, nurses and clinical staff can work around Versius without fear of it crashing into them.

Despite the lessons learned from other sectors, the underpinning technology - the software, hardware and electronics at the heart of the system – is largely bespoke. And this, said Haig, has required the company's suppliers to go on a bit of a journey. "Our innovations have really sparked the imaginations of some of the development teams in our suppliers. Sometimes there's the inevitable red tape of being a startup.... and trying to convince some cutting edge manufacturers to work with us on essentially nothing more than a prototype and a promise but once they've seen that potential they've engaged with us and they've come with us on that journey."

"THE ADVENT OF COLLABORATIVE ROBOTICS HAS ENABLED US AT CMR TO LEAPFROG THE INCUMBENTS"

The console is connected to the robot via a one gigabit ethernet cable

Arguably the most important partner of all though is the clinical community, and the team has worked closely with hospital teams, including a group at Addenbrookes in Cambridge to ensure that the technology is compatible with the reality of an NHS hospital. This is not just about ensuring the system meets the surgeon's requirements, but also that it fits into the workflow of the wider team. "The team [at Addenbrookes] have been involved from a very early stage," said Haig, "and we've expanded that out to nursing teams, as a lot of what happens in an operating room is a manipulated set- →

up connected together and positioned by nurses."

Hospital layout has also been a factor. "This can't be something that gets craned in, where we cordon off part of the hospital and it gets used for special occasions. This needs to be something everybody can use – something you can wheel in when you need it."

And of course, feedback from surgeons has been hugely important, particularly in terms of the system's ergonomic design.

According to the company's own research, around 76 per cent of surgeons in the UK experience muscular pain as a result of performing surgery, with many forced into retirement by the physical demands of the job. "A lot of surgeons retire early," said Haig, "and yet their peak from a skill level is in their sixties. We've spent a lot of time focusing on how we can improve the ergonomics of surgery so you're not standing with your arms up in the air with sharp instruments jabbed into the palm of your hands for eight hours a day with your neck twisted around looking at a screen on the opposite side of the room."

As well as prolonging the careers of surgeons, the ability to gather and analyse data from systems in the field could be used to help drive up skills. "We can benchmark people and say, 'OK this is where you are on the learning curve, these are the areas where comparatively you seem to be less efficient'."

Dr Dhananjay Kelkar led clinical trials of the system at Deenanath Mangeshkar hospital in Pune, India

Technology aside, one of the most remarkable things about the Versius story is the speed with which the company has grown given that its target market is one of the most heavily regulated sectors there is. Founded just five years ago, the firm now employs almost 400 people, and – according to its head of marketing Patrick Pordage – is doubling in size every 12 months.

Even more significantly, the technology is now poised to have a real-world impact. Clinical trials - announced earlier last year (April / May 2019) are ongoing in hospitals in Pune, India. At the time of writing upwards of 30 successful procedures had been performed and, according to the team, the first UK sale to an NHS hospital is imminent.

Five years from concept to patient is a pretty impressive achievement. And Haig, who has been with the company since the very early stages, puts this success down to a clarity of vision. "We've been extremely focused, we came from an informed background, we knew where technology could help in surgery, we had worked in different environments ourselves and we knew that if we were going to make this work we had to be pragmatic."

What's more, the fact that the firm has one core product has helped maintain that focus: "When you've got 400 people all with the same goal it really helps you cut through some of the politics. Everyone has one goal in mind, and that makes it much more straightforward".

It also makes for a pretty inspiring work culture. "There's nothing more satisfying than seeing your product being used in surgery on a person knowing that you have transformed that person's life," said Haig. "I burst into tears the first time I saw a procedure being done with Versius. It really is quite a special moment." THE ENGINEER

The ergonomically designed console is both intuitive to use and comfortable

ENGINEERING EVENTS/EXHIBTIONS 2020

JANUARY			
Consumer Telematics Show	6 January	**Planet Hollywood Hotel, Las Vegas, USA**	www.automotive.knect365.com
Predictive Maintenance 2020	14 - 16 January	**Berlin, Germany**	www.smartgrid-forums.com/PDM20ENGL
10 Best Engines & Propulsion Systems	16 January	**Marriott Renaissance Center, Detroit, USA**	www.wardsauto.com/2019-10-best-engines/2019-wards-10-best-engines-gasoline-diesel-electrification-honored
Common Information Model 2020	21 - 23 January	**Amsterdam, The Netherlands**	www.smartgrid-forums.com/CIM20ENGL
NextGen SCADA Global 2020	27 - 31 January	**Berlin, Germany**	www.smartgrid-forums.com/SCADA20ENGL
FEBRUARY			
Southern Manufacturing & Electronics	11 - 13 February	**Farnborough International Conference and Exhibition Centre**	www.industrysouth.co.uk
The IET Annual Dinner 2020	19 February	**JW Marriott Grosvenor House, London**	www.ietannualdinner.org
Utility Telecoms 2020	25 - 27 February	**Amsterdam, The Netherlands**	www.smartgrid-forums.com/UTC20ENGL
MARCH			
Energy from Waste Conference	4 - 5 March	**America Square Conference Centre, London**	www.efwconference.com
Cyber Security for Industrial Control Systems	5 - 6 March	**IET London: Savoy Place**	events2.theiet.org
Engineering Solutions Live (incorporating FAST Live, Engineering Materials Live, PCB Design & Manufacture Live & Make Measurement Matter)	12 March	**British Motor Museum**	www.engineeringsolutionslive.co.uk
DPSP 2020: Developments in Power System Protection	9 - 12 March	**ACC Liverpool, UK**	events2.theiet.org
Fundamentals of IEC 61850 Training Programme	17 - 19 March	**London, UK**	www.smartgrid-forums.com/FUNDIEC20ENGL
HPM Connect,	18 March	**Cranmore Park**	
Smart Grid Cybersecurity 2020	24 - 26 March	**Berlin, Germany**	www.smartgrid-forums.com/SGCS20ENGL
Nuclear engineering for safety, control and security	26 March	**Bristol Marriott Royal Hotel, UK**	events2.theiet.org
Battery Tech Expo	26 March	**Silverstone**	www.batterytechexpo.co.uk
AI&ML for the Smart Grid 2020	31 March - 2 April	**Brussels, Belgium**	www.smartgrid-forums.com/forums

APRIL			
Connected & Autonomous Vehicles 2020	6 - 9 April	**San Jose Convention Center, San Jose, CA, USA**	ww.tmt.knect365.com/connected-vehicles/
MACH 2020,	20 - 24 April	**NEC Birmingham, UK**	www.machexhibition.com
Utility Cloud 2020	April	**Amsterdam, The Netherlands**	www.smartgrid-forums.com forums/UCL20ENGL
Utility Innovation Forum 2020	April	**Lisbon, Portugal**	www.smartgrid-forums.com/forums
Focus: AI	April	**The Townsend Hotel, Birmingham, MI, USA**	www.wardsintelligence.com/focus-ai
MAY			
Grid Asset Management 2020	May	**Amsterdam, The Netherlands**	www.smartgrid-forums.com
UKIVA Machine Vision Conference	14 May	**Marshall Arena, Milton Keynes, UK**	www.machinevisionconference.co.uk
Façade Awards	21 May	**The Park Royal Hotel, Warrington**	www.facadeawardsuk.com
JUNE			
TU-Automotive Awards	2 June	**Hyatt Place, Novi, MI, USA**	www.automotive.knect365.com
TU-Automotive Detroit	3 - 4 June	**Suburban Collection, Novi, MI, USA**	www.automotive.knect365.com
IEC 61850 USA 2020	June	**USA**	www.smartgrid-forums.com/forums
Subcon 2020	9-11 June	**NEC Birmingham**	www.subconshow.co.uk
The Engineer Expo 2020	9-11 June	**NEC Birmingham**	www.theengineer-expo.co.uk
Comms Business Awards	18 June	**Royal Lancaster Hotel, London**	www.commsbusinessawards.co.uk
JULY			
Additive International	14 - 16 July	**Trent Bridge Cricket Ground, Notts**	www.additiveinternational.com
SEPTEMBER			
Connected Car Insurance USA	1 - 2 September	**Chicago, MI, USA**	www.automotive.knect365.com
Fundamentals of the Smart Grid Training Programme	September	**Amsterdam, Netherlands**	www.smartgrid-forums.com/FSG20ENGL
Smart Grid Big Data 2020	September	**Amsterdam, The Netherlands**	www.smartgrid-forums.com /SGBD20ENGL
GIS4SmartGrid 2020	September	**Amsterdam, The Netherlands**	www.smartgrid-forums.com/GIS20ENGL
ADAS & Autonomous Vehicles 2020	September	**Novi, MI, USA**	www.automotive.knect365.com
PPMA Show 2020	29 Sept - 1 Oct	**NEC, Birmingham, UK**	www.ppmashow.co.uk
OCTOBER			
Smart Grid Flexibility 2020	October	**Amsterdam , The Netherlands**	www.smartgrid-forums.com/SGF20ENGL
Northern Manufacturing & Electronics	7 - 8 October	**Event City, Manchester**	www.industrynorth.co.uk
British Engineering Excellence Awards	9 October	**The Landmark London**	www.beeas.co.uk
The Engineering Design Show 2020	14 - 15 October	**Ricoh Arena, Coventry**	www.engineeringdesignshows.co.uk
IEC 61850 Global 2020	26 - 30 October	**Brussels, Belgium**	www.smartgrid-forums.com/IEC6185020ENGL
EuroBLECH 2020 26th International Sheet Metal Working Technology Exhibition	27 - 30 October	**Hanover, Germany**	www.euroblech.com 2020 english
NOVEMBER			
The Engineer Collaborate to Innovate Awards 2020	4 Nov	**London**	www.theengineer.co.uk
TU-Automotive Europe	November	**Dusseldorf, Germany**	www.automotive.knect365.com
DECEMBER			
Pitched Roofing Awards	3 December	**The Midland, Manchester**	www.pitchedroofingawards.co.uk

DIGITAL DELIVERY

Babcock's managing director for technology Dr Jon Hall explains how an innovative approach to data is at the heart of the firm's technology strategy.

JON EXCELL REPORTS

Despite being one of UK engineering's biggest, most respected and most enduring names, it's probably fair to say that Babcock International Group doesn't immediately spring to mind as one of its most nimble innovators.

And that's not a bad thing. Indeed, when your core business is managing critical assets ranging from nuclear power stations to warships, it's probably better be viewed as a safe pair of hands than as a risk-taking technology swashbuckler.

And yet, as the firm's technology director Dr Jon Hall recently told *The Engineer,* the company's key role of finding ever more effective ways to boost the performance and efficiency of assets across its key sectors of defence, civil nuclear and the emergency services is in fact driving a significant level of innovation.

"We've generally got big expensive, complicated assets with a long, long lifecycle," Hall said. "If you want to get more life out of an advanced gas reactor you've got to think what are the tools and techniques we can apply to justify getting more life out of it? If you look at Type 23 frigates, past their design life, what are all the ways we can get more capability on the ship?"

At the same time, the firm is also tasked with hitting some pretty demanding cost-reduction targets: around 25 – 30 per cent in naval maritime support, and as much as 30 per cent in nuclear new build.

It's a hugely challenging balancing act, and one of the keys to pulling it off, said Hall, has been the growing application of data and digital technologies. "We've been up that curve of the easy savings in terms of working more effectively, by people doing their jobs a bit faster, and so on. But you get to the point where you need to make a bit of a step change, and the data and digital enablement is about making that next step that gets us the extra ten to fifteen per cent improvement in cost."

In a world where data has become something of a buzzword, Hall was keen to stress exactly what it means for Babcock. "What you generally hear about is the big data stuff: throw me petabytes of data and I'll find patterns in it and tell you how to sell more Coke cans. But there's no engineering insight in that. With the sort of stuff we look at either data is not fully available or is of poor quality, so we find ways of putting that together with a white box model where we've got a system engineering understanding of the asset. We know what's important and what will probably affect the performance and maintainability and cost of it and we can plug the right data together with that understanding."

At the heart of Babcock's offering in this area is the concept of the digital twin: a digital representation of a physical asset updated using real-time data, which helps engineers to understand the performance, efficiency and status of the asset.

While Digital twin technology is now used widely across the business, one particularly striking illustration of the technology in action is its use in the operation and maintenance of one of The Royal Navy's most powerful weapons: the 4.5 inch gun used on all of its destroyers and frigates.

Hall explained that by using digital twinning to constantly gather data about the performance of the system, Babcock engineers are able to constantly monitor the performance of the gun, spotting emerging faults before they become an issue and optimising maintenance operations accordingly.

Unsurprisingly, digitalisation will also be at the heart of Babcock's work on the Royal Navy's new Type 31 Frigate, for which it won preferred bidder status earlier this year. Hall said that investments in the Babcock's Rosyth dockyard will see the vessels "built in a way that transforms how ships are built" and talks of a digital thread that encompasses everything from the design of the vessel right through to the so-called iFrigate data analytics system that will support them once they take to the sea.

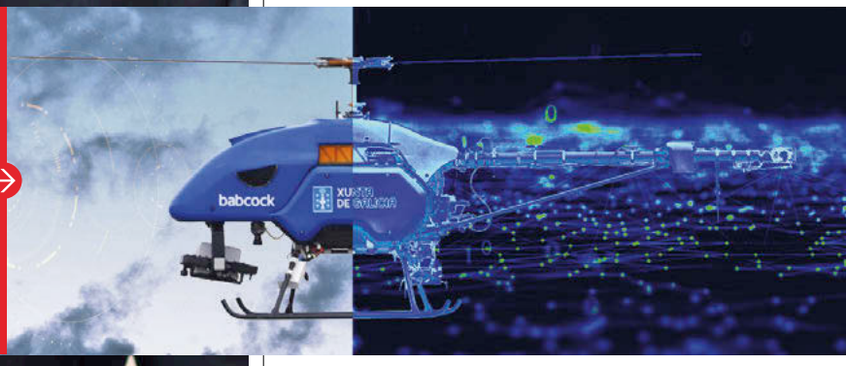
A very different, but no less eye-catching, showcase for Babcock's data expertise is its development of a specialised drone designed to help aerial emergency services fight wildfires.

Developed by the group's innovation team in Spain, Lua (Light Unmanned Aircraft) - which has a payload capacity of 7kg and is capable of several hours of autonomous flight – is an impressive piece of flight hardware. But it's the drone's role as part of a joined-up data system that will help emergency services direct fire-fighting assets, and even feed into real-time

simulation that will predict the behavior of a fire, that's the key innovation.

Whilst digital solutions are increasingly at the heart of everything Babcock does, Hall is keen to stress that the technology is nothing without the people. Ultimately, he said, it's about using technology to empower engineers to make informed decisions quickly. "There's lots of underpinning investment in ERP systems and data systems, and lots of investments in digital twins, but all that is there ultimately to lead towards something that lets you make better

"WE'VE GOT OUR ARMS AROUND SOME OF THE MOST EXCITING BIG ASSETS, AND THAT MAKES BABCOCK AN ATTRACTIVE PLACE"



(Left) CGI of The Royal Navy's new Type 31 frigate, which will be built at Babcock's Rosyth facility (right) Babcock's LUA drone gathers data on the spread of wildfires and helps inform firefighting decisions

decisions for or with your customer. The most important thing of all is that it gets us close to the customer...that the customer is sat there with us sharing the same data on the same data platform with us enabling them to make better decisions."

Nevertheless, the growing importance of digital technology is having an impact on the types of skills that the company requires, and while there's always going to be a need for mechanical engineers or electrical engineers, Hall pointed to a growing requirement for non-traditional areas of expertise. "If you look back a couple of years, only in niche parts of our business were we recruiting data scientists and cyber analysts, but now that's a real career path for us, and we're developing a scheme where people can join Babcock as a data scientist and have a career path and move around the business."

With data science skills in huge demand across a variety of sectors, industry has faced some well publicised challenges competing with trendy tech startups for the brightest young minds in the field. But whilst Hall admits that Babcock has had to think creatively about how to engage with this emerging generation of experts he believes that engineering is increasingly being seen as an attractive destination. "It's a really hot market. We've got offices in nice locations and all the cliched things you'd expect with some tech teams - If you go into their office you'll be shot at with a Nerf gun! But we do find in the engineering space we're attracting a different sort of graduate who I think is motivated by what the outcome is. Do they want to go and do data science that enables Mike Ashley to sell more tracksuits? Or do they want to do data science that keeps the aircraft carriers at sea? I think there's a cohort of people that wants to be in a big engineering organisation and be able to do all that funky stuff. It's a hot market, but we've got our arms around some of the most exciting big assets, so I think that makes Babcock an attractive place." THE ENGINEER

THE POWER OF PARTNERSHIPS

An expert panel discusses the benefits and challenges of collaboration in the engineering sectors

JON EXCELL AND STUART NATHAN REPORT

At a time of rapid technological change, when the boundaries between once distinct engineering disciplines and sectors are becoming increasingly blurred, collaboration has never been more important.

Indeed, sharing expertise, knowledge and different approaches to problem solving is frequently the key to addressing the big challenges we face as an industry and a society.

The fruits of this process are at the heart of many of the stories reported on by The Engineer and are also celebrated through our annual Collaborate to Innovate (C2I) awards competition. But collaboration isn't without its challenges: How do you instigate collaborative partnerships? How do you structure a collaboration to be sure that you're not surrendering a competitive advantage? And how do you overcome the cultural barriers (and differing vernaculars) of different sectors and disciplines?

Last year (November 2019) The Engineer - in partnership with the High Value Manufacturing Catapult - brought together a panel of experts to discuss these issues, ponder the importance of driving strong collaborative relationships and identify some of the key factors that drive effective and successful engineering collaboration.

As you'll discover over the following pages, our diverse group of experts – which included representatives from industry, academia, and "match-making" organisations set up specifically to drive collaboration - had plenty to say on the topic. We hope this special report provides some useful food for thought for anyone looking for pointers on how to collaborate effectively.

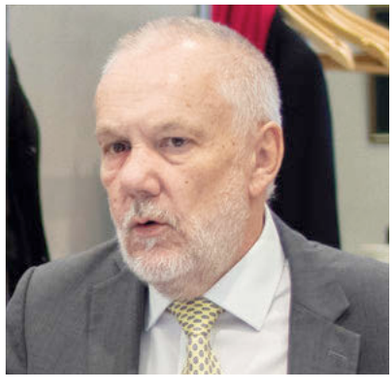
Dan Bunting - Head of Business Development, Advanced Propulsion Centre

WHY COLLABORATE?

We began by asking our panellists to explain why they thought collaboration was valuable. Small business operator, and C2I 2019 winner, James Widmer put it in simple terms: "there's only 17 of us at the moment, and you can't do everything yourself. Equally, a lot of the time you can't afford to pay to do everything yourself. If you can find a small group of companies or university researchers that you can bring together, you can do everything in a much more pragmatic way." As Nottingham University's Richard Hague put it, "very often organisations will have a view that they can do everything, but they cannot. It's absolutely essential to bring in collaborators to fill the gaps."

> **"WE'LL GET THE BEST RESULTS IF WE REACH OUT ACROSS DISCIPLINARY BOUNDARIES AND ENCOURAGE DIVERSITY"**

Engineering is particularly dependent on collaboration because by its very nature it is multidisciplinary, and becoming more so. John Lazar, a software engineer who has been involved in many collaborations across different sectors, pointed out the rate of change. "There's a bigger challenge for us at the moment in a world which is changing extraordinarily quickly, where we have really rapid exponential change, particularly with things like AI and machine learning. We will get the best results if we, as engineers, reach



Tim Armitage - Associate Director, Arup

out across disciplinary boundaries as much as possible and also encourage diversity."

COMMUNICATION

One of the key factors to effective collaboration is good communication, but when you're working with specialists from different disciples and sectors this isn't always as easy it sounds.

As Prof Richard Hague pointed out, many different sectors have their own vernacular, and cutting through this is essential if you're going to make real progress together. "Language is really important," he said. "Very often people are talking about the same thing, but just with different words. Learning to understand other people's vocabulary is really, really important."

CMR Surgical's Fiona Haig is at the sharp end of this process. Through the development of her firm's Versius robot arm (see more on page 26) she's had to collaborate closely with surgeons and clinical staff.

The key to achieving this, she said, has been building a truly cross disciplinary team. "My team is a mix of software engineers, electronics engineers, bioengineers, medics and nurses. We are all the development team. But by everybody sort of stepping over into the other person's camp and trying to understand what they mean by a piece of terminology....and being able to step outside your lane and really blur the edges has really helped."

Another panel member with direct experience of the challenge of communicating with specialists from completely different fields is Arup's Tim Armitage.

Through the Arup-led UK Autodrive Project, a former winner at *The Engineer*'s C2I awards and one of the UK's largest trials of driverless car technology, Armitage led a team of consisting of engineers, but also local authority representatives, motor insurance firms and even the general public. A key lesson learned through this project, he said, was going into the early conversations with a completely open mind. "One of the things we realised is that you have to work together to break things down on both sides until you reach a point where you can start talking ...don't be afraid of asking the stupid questions."

Meanwhile, reflecting on his earlier career in the motorsport sector, Frazer-Nash Consultancy's Peter Van Manen said that smart use of data can help inform clear communication between partners. "When we started first using data in motor racing back in the 1980's, one of the primary reasons was to provide a common language... to allow collaboration between someone who didn't know engineering and someone who didn't know how to drive racing cars."

Ultimately, added Fiona Haig, it's about trusting your partners. "Go into the relationship assuming it is going to work. Go into it saying 'we both want to be here, I know you can bring something to this, I can bring something to this' and assume you're going to be a success. Start positively and try to keep it that way.

Dr John Lazar - Royal Academy of Engineering

MEET THE PANELISTS

Dr John Lazar CBE - Royal Academy of Engineering

Prof Richard Hague - Director of Centre for Additive Manufacturing, University of Nottingham / Director - Added Scientific

Dr Peter van Manen - Service Development Consultant, Frazer-Nash Consultancy

Rosa Wilkinson - High Value Manufacturing Catapult

Dan Bunting - Head of Business Development, Advanced Propulsion Centre

Fiona Haig - Head of Clinical Engineering, CMR Surgical

Tim Armitage - Associate Director, Advanced Technology and Research Group, Arup

Dr James Widmer - CEO, Advanced Electric Machines Group Ltd

Business Academia Collaboration

Many of the UK's most fruitful collaborative projects are between businesses and academia. But such projects can only get going if the participants can find each other in the first place. Richard Hague, who as well as leading a research group also runs a spin out business, is well aware of the role that universities can play in this, and how researchers can ensure that they are visible to potential industrial collaborators. →

"I'm amazed how many companies will come to us....having read one of our general publications, and say, well I read your paper on this, and we're working in a related area. Publicising yourself well is useful. Whether you do it through a website or general publication, you have to get the message out."

However, not all collaborations are between business and academia. James Widmer pointed out that inter-company collaborations can also be very fruitful. "Something I've seen more in other countries than the UK is this sort of a critical mass thing. In the electric motors world, there is some fantastic stuff going on. A lot of companies who you think might normally compete, actually tend to work quite closely together."

He added, that the German Mittelstandt concept of small companies with common interests working together on non-competitive projects is very effective. "Bringing together all these little companies working together, even if on the surface of it, they compete, has made a huge difference. In the UK, we tend to like to compete amongst ourselves. Sometimes, looking at the bigger picture, and trying to aggregate what we're all doing, is very sensible."

Collaboration champions

Panelists agreed that organisations like the High Value Manufacturing Catapult and the Advanced Propulsion Centre are playing an important role in helping to create this collaborative culture.

Widmer said that by acting as magnets for smaller, innovative companies, such initiatives are helping to create collaborative pockets of excellence in key emerging areas. "[They help us] look at how we can work

together to get to where we all need to be rather than fight amongst ourselves" he said.

Rosa Wilkinson added that many of the centres that make up the HVM catapult actively stimulate this through their membership models. "Some of our centres have a membership model, where part of the membership fee people pay....goes into a big pot and together the members agree how that pot is going to be used, on projects which are actually of interest to a large number of them."

APC's Dan Bunting also championed this approach. "There are so many challenges or opportunities... and you can't do them all," he said. "Single organisations can't decide on a strategy and put things in place and go through their processes."

Managing risk

When companies become involved in collaborations, there is often an element of risk. Business practices, processes, and intellectual property may be opened up to outsiders. Such risks may put many companies off the idea of collaboration, despite its potential advantages.

Peter van Manen insisted that managing risk should be built in from the very beginning. "Risk is something that gets in the way of innovation," he commented. "The innovation process doesn't come with any guarantees. And that matters not only to the individual company, but to the company's investors."

The legal framework underpinning collaborative projects is crucial, he added. "It's essential to have that framework upfront. But really the

Bottom left, Rosa Wilkinson; Above left, Fiona Haig, below, James Widmer

collaboration is amongst the engineers and scientists that take the project forward. It's not the legal experts in the companies that take that forward.

Tim Armitage, whose work on projects like Autodrive has seen him collaborate with financial organisations, insisted that setting up this legal framework at the outset of the collaboration helps to ensure that the way it will be run is clear. "You need clarity" for the project to proceed smoothly, he said. "The legal framework is a is a form of clarity, but this is where you need clarity not only on what you're trying to achieve. You also need a way of monitoring that, so you can say we're going in the right direction or we're going a bit off-piste."

James Widmer spoke about ensuring that the risk is balanced between collaborating organisations. Openness about the limits of the project is vital, he said. "It's all very well bringing experts together. You can set them up with great ideas, and they talk candidly to each

other, but the trickiest thing is getting everyone to trust each other, and putting the framework in place that enables that relationship to actually work."

Skills

Every debate about the current state of engineering is somehow concerned with skills. Collaboration is no different, and the panellists were agreed that often the way that engineering is taught contributes to problems. The expression "siloing" cropped up often in the discussion. "So much of engineering training at university is so deeply siloed that you get people coming out of university who really struggle with working with people in other disciplines," John Lazar commented. With this being an essential skill for collaborations, especially in sectors which cross boundaries by their nature, this can be a disaster, the panel agreed.

Sometimes, collaborative thinking has to be taught, he added. "One approach I've heard of is bringing computer scientists and engineers in with creatives in a horizontal space

"RISK IS SOMETHING THAT GETS IN THE WAY OF INNOVATION. THE INNOVATION PROCESS DOES NOT COME WITH ANY GUARANTEES"

Peter van Manen - Service Development Consultant, Frazer-Nash Consultancy

where they are literally forced to work together on fashion and music projects at an early stage. I would bet that people coming off these projects are much more open to thinking about wider collaboration." Unorthodox methods like teaching theatrical improvisation skills could also be fruitful, he suggested, and Richard Hague added that people who have already shown a facility for learning languages are often good at this kind of thinking.

James Widmer also advocated this type of approach. "I got involved with Coventry University because of their Advanced Manufacturing Engineering Institute," he said, "where you're putting people into real work situations, they have to actually engage with real people doing real things and learn from that."

Prof Richard Hague - Director, Centre for Additive Manufacturing, University of Nottingham

Use the tools

One very simple way in which communication challenges can be overcome is by using the practical tools that are available: from digital twinning systems that engage every member of a team in the development cycle, to the plethora of platforms that make it easier for us to talk to each other

"I think the tools have improved," said John Lazar. "They're still not perfect, because you get too much volume of information. But you

COLLABORATION BLUEPRINT

- Establish a legal framework for collaboration from the beginning
- Agree the target of the project upfront and ensure the whole team is aware of the end goal
- Be honest about what can and cannot be done.
- Go into the relationship assuming it is going to work but accepting there will be challenges along the way.
- Ensure that the collaborative team has its own identity and is not defined by the affiliations of its members.
- Talk to project partners every day, and schedule weekly catch-ups with the whole team
- Celebrate milestones and other notable achievements.
- Try to see things from your partners' point of view
- Standardise communication and other collaboration tools

can see big virtual teams working together much better now than 15, 20 years ago. So I think a combination of communication tools, project management, and tracking stuff is much better than it was. You have to be really, really careful about how you use them and how you manage them but when they're used well, they're brilliant."

Rosa Wilkinson cautioned that there is a skills dimension to the effective use of these technologies. "It really is a question of expertise," she commented. "Making use of some of these digital tools requires a skill set as well, which not all firms will have."

Panellists also discussed the pros and cons of the plethora of virtual conferencing facilities that are now available. Whilst agreeing that anything which aids daily communication is positive, there were some misgivings over the capabilities of current systems. "I haven't found any of them very helpful as tools," complained James Widmer "I don't know why they're not better, really."

Others disagreed, Richard Hague said conferencing tools have become absolutely key to his group's work with external partners, and that providing that meetings are correctly structured, the technology is effective and easy to use.

As well as good housekeeping, standardising on one system and sticking with it, rather than flitting between a multiplicity of different conferencing systems, was a key piece of advice. "Something as basic as just using one tool has made a huge difference," said Fiona Haig. THE ENGINEER

ROSA WILKINSON

Collaborate to Succeed

By pooling resources companies are achieving more than they could ever do alone, writes Rosa Wilkinson, director of communications at the High Value Manufacturing Catapult

We can be proud of the UK's manufacturing heritage. As the world's first industrial nation, the UK has been the birthplace of many of industry's keystone technologies and continues to provide a home to world-leading sectors such as aerospace, pharmaceutical and automotive. It has long enjoyed a healthy national income from the efforts of its businesses which together support millions of jobs and make a significant contribution to our national prosperity.

All of that's good news, but this positive overview doesn't quite tell the whole story. True, the UK has its share of firms who are up there with the global leaders when it comes to making productivity improvements, but too many still have some distance to travel to master the productivity challenge and be globally competitive. At a time of intense market competition, the danger is these firms will be left behind as customers migrate to other suppliers offering better goods and services at better prices.

But here's the problem: no matter how strong their appetite, few firms have all of the assets they need to make changes that will bring a bloom to their bottom line and deliver the industrial impacts the country needs. That's not just weakening company performance, it's holding back our national progress towards improved productivity, better working conditions, lower carbon emissions and a reduced environmental impact. Collaboration is the ingredient that changes the game. Through collaboration, companies can open up vast funds of insight, talent, and access to the sometimes costly equipment that can help to transform their operations.

That's where organisations like the High Value Manufacturing Catapult play such an important role. Collaboration is in our DNA. We bring innovation hungry businesses together with world-leading technical experts to help boost company competitiveness and develop the products and processes that capture and secure market share. We know that when people collaborate, difficult problems can be overcome and great results emerge. We deliver the support needed to help firms translate new knowledge into the world-beating products and processes that will boost their balance sheet, help create new high-quality employment and increase prosperity.

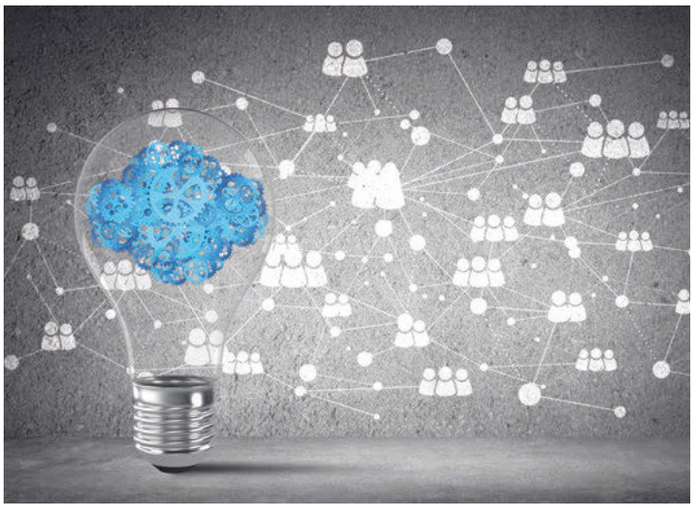
The support we offer is about far more than our kit and technology expertise. A key part of the value we add comes from the collaborative relationships we can inspire through the supply chain. Take our Fit For Nuclear (F4N) supply chain development programme at the Nuclear AMRC. It helps UK manufacturing companies get ready to bid for work in the civil nuclear supply chain. It helps companies to measure their operations against the priorities of those at the top of the supply chain and the standards required to supply the nuclear industry – in the global growth areas of new build, operations and decommissioning – and take the necessary steps to close any gaps.

Since our creation in 2011, we have collaborated with tens of thousands of firms of all shapes and sizes to harness new technologies. Through our seven centres around the UK, we have built up a unique insight into what manufacturers need, where manufacturing technologies are heading and what is needed to exploit them. That's allowed us to guide our investment towards building capabilities in the areas most likely to deliver a robust return for the nation's manufacturers: digital manufacturing, robotics and automation, materials processing and new materials, process engineering, biotechnology and biologics and the design and verification of products.

Ultimately, the High Value Manufacturing Catapult exists to make sure all manufacturing businesses can harness the power of innovation to speed their path to success. We give every firm we work with access to a unique repository of expertise and the equipment they need and then apply the good collaboration principles to take a new idea from concept to proven process or product. The precise roadmap is different for every company but whatever its shape, by giving companies access to the things they need but don't have under their own roofs, the HVM Catapult helps open up untapped potential, create new opportunities and strip away the risk of innovation to deliver great results. For us, collaboration is the elixir of company success.

THE ENGINEER

"COLLABORATION IS THE INGREDIENT THAT CHANGES THE GAME"



CATAPULT
High Value Manufacturing

Working with
Innovate UK

Your High Value Manufacturing Catapult

The go-to place for advanced manufacturing technologies in the UK

Seven world class centres of industrial innovation with a burning ambition to grow your business by helping you turn great ideas into commercial realities.

We provide access to the specialist equipment and expertise you need to help investigate new technologies and processes and test their application in your operation. We help you strip away the risks of innovation and make sure that you only invest when you are confident that your idea can be scaled up to deliver on a commercial scale.

Our services are available to firms of all shapes and sizes from FTSE-listed companies to small firms deep in the supply chain. Our offer is built on:

- capability which spans basic raw materials through to high integrity product assembly processes
- world-class facilities and skills to scale-up and prove high value manufacturing processes
- a network of leading suppliers who contribute to key UK industry supply chains
- a partnership between industry, government and research in a shared goal to make the UK an attractive place to invest in manufacturing

Our ambition is to grow your business and support the growth of manufacturing in the UK economy.

Find out more:

hvm.catapult.org.uk

+44 (0)1564 711 540

info@hvm.catapult.org.uk

@HVM_Catapult

SIZE MATTERS

Stuart Nathan speaks to Bella Trang Ngo, who is on a mission to use technology to help support women in the most literal way

We often say at The Engineer that engineering intersects with people's lives in many ways that are overlooked by the public, particularly when reporting on efforts to inspire young people to consider engineering as a career. But Bella Trang Ngo is taking that to a level we have not encountered before. While it's true that clothing design and manufacture is an overlooked sector of engineering, Ngo is using some of the most advanced weapons in the engineering armoury to ensure that one particular item of clothing fits better. Namely, bras.

Considering the gender make up of UK engineers (just 12.37 per cent are female) it's likely that many people reading this will not realise how serious or widespread the problem of ill-fitting bras is.

According to Ngo, around 80 per cent of women wear bras that do not fit properly, and the consequences can be severe. It's not just a matter of the discomfort we all encounter when clothes don't fit properly. If bras provide inadequate support, whether this is because they are too large or too small, the mechanical stress and loading this

causes on the body can lead to poor posture, chronic back and shoulder pain and even migraines.

"The loading goes onto the shoulder muscles and that directly affects the neck, and all the nerves that pass through it into the central nervous system," Ngo explained.

"We are talking about 70 per cent of women who experience breast pain on almost a daily basis that is not cancer related, for example. And that leads to self-confidence and self-image issues on top of the physical problems. Just all because of a poor fitting bra."

Ngo's response to this has been to work with fellow students at UCL to develop a system based on machine vision and artificial intelligence to ensure that women can find a bra that fits correctly. A business studies student herself, Ngo has worked with Prashant Aparajeya, a machine vision scientist at Goldsmiths University, to design the system which is now at the centre of a company she has founded called Brarista. The endeavour recently earned her a highly commended award in the Royal Academy of Engineering's Launchpad competition, entitling her to mentoring and training support through membership of the Academy's Enterprise Hub.

The business model behind Brarista is that manufacturers and retailers pay to use the service, which prospective customers then access through a smartphone app. They are then directed to put on what they believe to be their comfiest, best-fitting bra and take photos of themselves in front of a mirror (or get somebody else to take them) in several specified positions. They also fill out a short questionnaire on the price range in which they wish to shop, and the sort of outfit they are expecting to wear with the bra they are looking for.

These images are then fed into the system's algorithms, which analyse them in the same way that a trained bra-fitter would, to asses whether the bra the customer is wearing actually fits them properly. It does this by encoding the skills of a bra fitter who works by sight, rather than by using a tape measure. "We can't disclose how many photos a user needs to take or how the algorithm works, because we are still in the process of obtaining a patent for it," Ngo said. "But we have a specialty and expertise and understanding of how the breast shape and size and the bra size correlate and we have worked on building a data set that is proprietary to us to train our system to make sure that what we are producing is at grade."

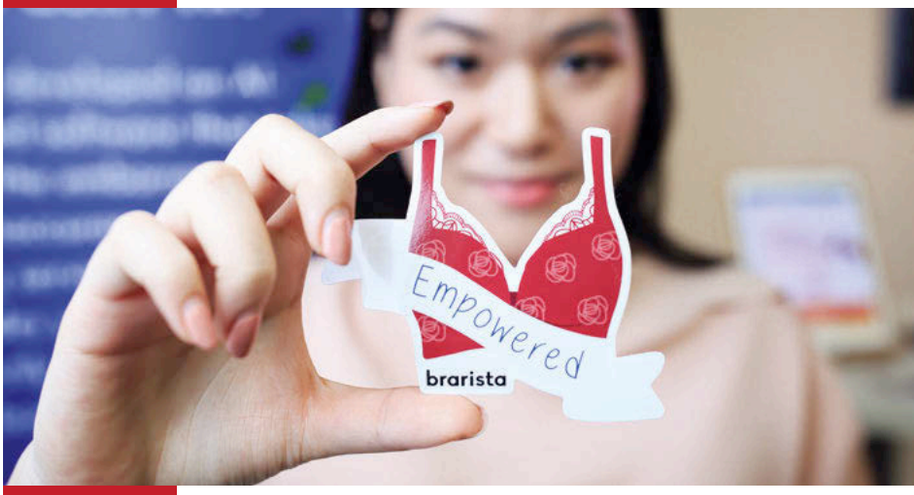
Ngo herself is a professional bra-fitter. "When I was doing a Masters in technology entrepreneurship at UCL, the nature of the course is that you have to find a real world problem that can be solved by technology, I was looking at different things that can be done to help a woman with bigger breasts, because I'd heard that 80 per cent statistic, which I was a bit cynical about; I thought it was just to get women to buy more bras.

"I did some market research and completely randomly, I met a professional bra-fitter who worked at Rigby & Peller at the time, it's the shop that used to fit the Queen's family. All she had of me was a picture of myself on Facebook and she asked me what size I was wearing. When I told her, she said not only was I in the wrong size but I was five or six sizes smaller than I should be wearing. I was in disbelief, thinking there's no way that's the case. We met up and she brought me the size I never thought I would ever be and I never felt better. It literally made me feel like a different woman. The way I stand, the pain of my neck and my chest area all improved almost instantly."

It was this encounter which led to her being trained as a bra-fitter and also inspired the project which led to Brarista. The most common method of bra fitting in High Street stores, using tape measures, is only accurate in about 30 per cent of cases, Ngo added.

Ngo is conscious of the privacy concerns that might worry potential customers and assured The Engineer that none of the photographs used by the system are stored and are deleted after processing. The customer receives a list of bras from Brarista retailer partners that, according to the algorithm, would be a good fit, and the option to buy one online

Ngo's Brarista concept uses AI and machine vision technology to address the problem of ill-fitting bras



Ngo is Vietnamese and UCL's innovation enterprise development sponsors her to stay in the UK on an exceptional talent tier 1 visa. "They also supported me with free coworking space in Kings Cross and mentorship support as well," she said.

Two weeks after winning the Enterprise Hub membership, Ngo had not yet been matched up with a mentor but said that she had had contact with the Gammon family who sponsor the RAEng award, who had indicated they would be keen to work with her on an ongoing basis to support the project. The Enterprise Hub mentorship is scheduled to begin in January.

"The motivation that keeps me in the business is I truly believe that women deserve a better way of shopping for bras offline and online," said Ngo. "It's time that we make sure that everything that women buy works for their body. More than 80 per cent of women's clothes bought online are returned, so that is a lot of money and a lot of time lost on the end consumer side, but it also has an environmental impact. Systems like this - and there are an increasing number of them - could help significantly reduce that impact and wastage of time and money." THE ENGINEER

// 70 PER CENT OF WOMEN EXPERIENCE BREAST PAIN ON AN ALMOST DAILY BASIS ALL BECAUSE OF A POOR FITTING BRA //

DESIGN FREEDOM
Printing in carbon fibre allows strteamlining of bike frame design, such as the elimination of seat stays

AM in the frame

As the world's first 3D-printed bike frame hits the market Stuart Nathan investigates the advantages of additive manufacturing for the bicycle industry

STUART NATHAN REPORTS

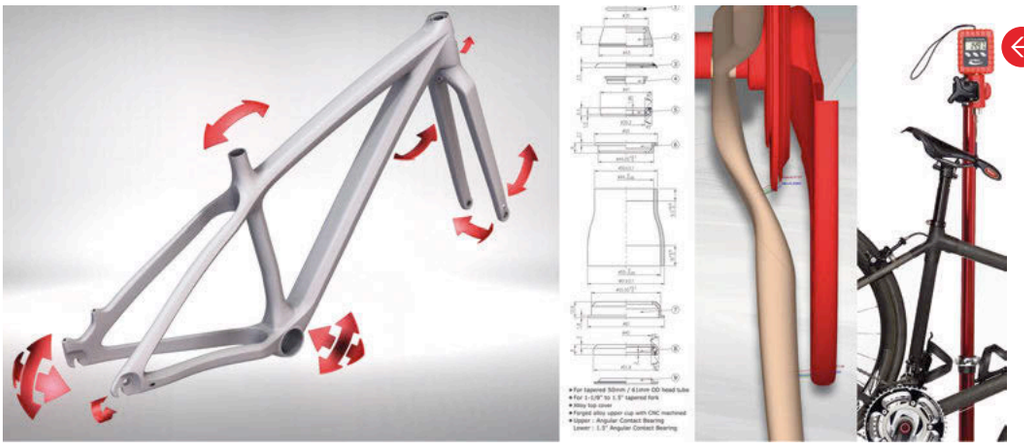
Since additive manufacturing (AM) has become more mainstream, the hallmarks of its use are increasingly familiar: radical curves, branching structures, shapes reminiscent of bone and coral. A cursory glance at the frame of the Emery e-bike reveals none of this: it's quite a different shape from a traditional bike, but the geometry seems quite simple and it's based around the familiar triangular structure that has formed the basis of frames for over a century. The viewer might think that perhaps the frame has some exotically-shaped reinforcing structure inside its tubes. But no, like any other bike frame they are hollow. Why then, you might ask, bother 3D-printing it at all? It looks like it could be made perfectly well using conventional manufacturing methods.

The frame came about because of a desire by Silicon Valley additive manufacturing specialist Arevo to find a commercial product to demonstrate the advantages of the process it has pioneered for printing carbon fibre-reinforced composites, which it has until now employed for aerospace components.

Deciding that a bicycle frame would be attention-grabbing, the company spoke to the last American winner of the Tour de France, Greg LeMond, who had been impressed by its technology during a visit. LeMond suggested they contact Bill Stephens of Studiowest, a Colorado-based sporting goods design consultancy. Stephens is a veteran bicycle designer, with experience in working in carbon fibre for high-performance frames.

Arevo's printing process works by placing continuous strands of carbon fibre using a printhead mounted on a robot arm. As with most 3D-printing systems, it's as much about the design software as the printing hardware. Arevo's systems work by performing finite element analysis of different orientations of fibres to determine how the forces and stresses of usage will affect the final printed article. This allows the composition of the piece and the internal structure of the composite to be optimised in a similar way to the geometry optimisation of a more familiar powder bed-printed article with its distinctive bird-bone shapes.

Stephens admits to having doubts when first approached. "I'm pretty sure Arevo thought 'we make aerospace components. How difficult can a bicycle be?' so I gave them my perspective. Bicycle frames are very challenging. There are many points where they have to withstand multiple dynamic forces from different directions at once. The consequence of failure can be severe inury to the rider. The tolerances are extremely tight because of all the moving components in a very small area and the need for the human rider to be able to move unimpeded. And bicycle designers are obsessed with reducing weight. I wouldn't have been surprised if they'd decided to go for something like a tennis racket instead. But to their credit, they



FORCE IS WITH YOU
(Left) Bike frames have to cope with dynamic forces at several points; (centre) clearances between bike components are often very tight; (right) overall weight is low for printed carbon fibre

decided to embrace the difficulties and stick with the bicycle idea."

"There was definitely an education both ways, where they taught me about materials and I taught them about all that's going on dynamically and from an engineering standpoint with a bike frame."

As to why 3D print was used, Stephens explained that the big advantage is the ability to make engineering items without tooling. "To design a carbon frame, we currently have to sit down - designers, engineers, marketing people - and forecast years in advance what we think is going to sell. We then design and engineer like crazy. At a certain point, we have to put the pencils down and write a big cheque to a toolmaker, who then spends weeks or months cutting steel. Those steel moulds we now own, and you're locked into that design for the life of the product."

"And then there's the production process. Your production team lays in the carbon fibres by hand. There are inevitably inconsistencies from one frame to another, because even the most skilled person can't produce identical work every time. It's a lengthy process – tens of hours per frame - and that limits the number of units you can produce and consequently keeps the price high."

"The Arevo process just kind of turns all that upside down. There's no need to forecast that far out ahead; and we're not locked into any single design. In the bicycle world, there's a lot of trends in components. These are all changes that are prohibitively expensive, when you've got to cut into those steel moulds. With the print on demand process, any change that we choose to make to the design can be a software change. The next print can reflect a different physical geometry. That's a kind of design freedom and flexibility that doesn't exist today."

"Moreover, you can print a run of 1000 frames faster than conventional carbon builds and be confident that every one will be identical."

> **"IT'S COMPLETE FREEDOM TO SET ASIDE PRECONCEIVED NOTIONS. THAT'S VERY EXCITING TO ME AS A DESIGNER"**

As the project progressed, Arevo developed its process to accommodate a much larger print volume, which made it possible to consider printing the entire bike frame as a single part. "Initially, I thought, this is big enough to at least print one side," Stephens said. "And then, I threw out to the team what I thought was just a radical idea, to print the whole frame as one piece, but I didn't think they were going to be able to do it."

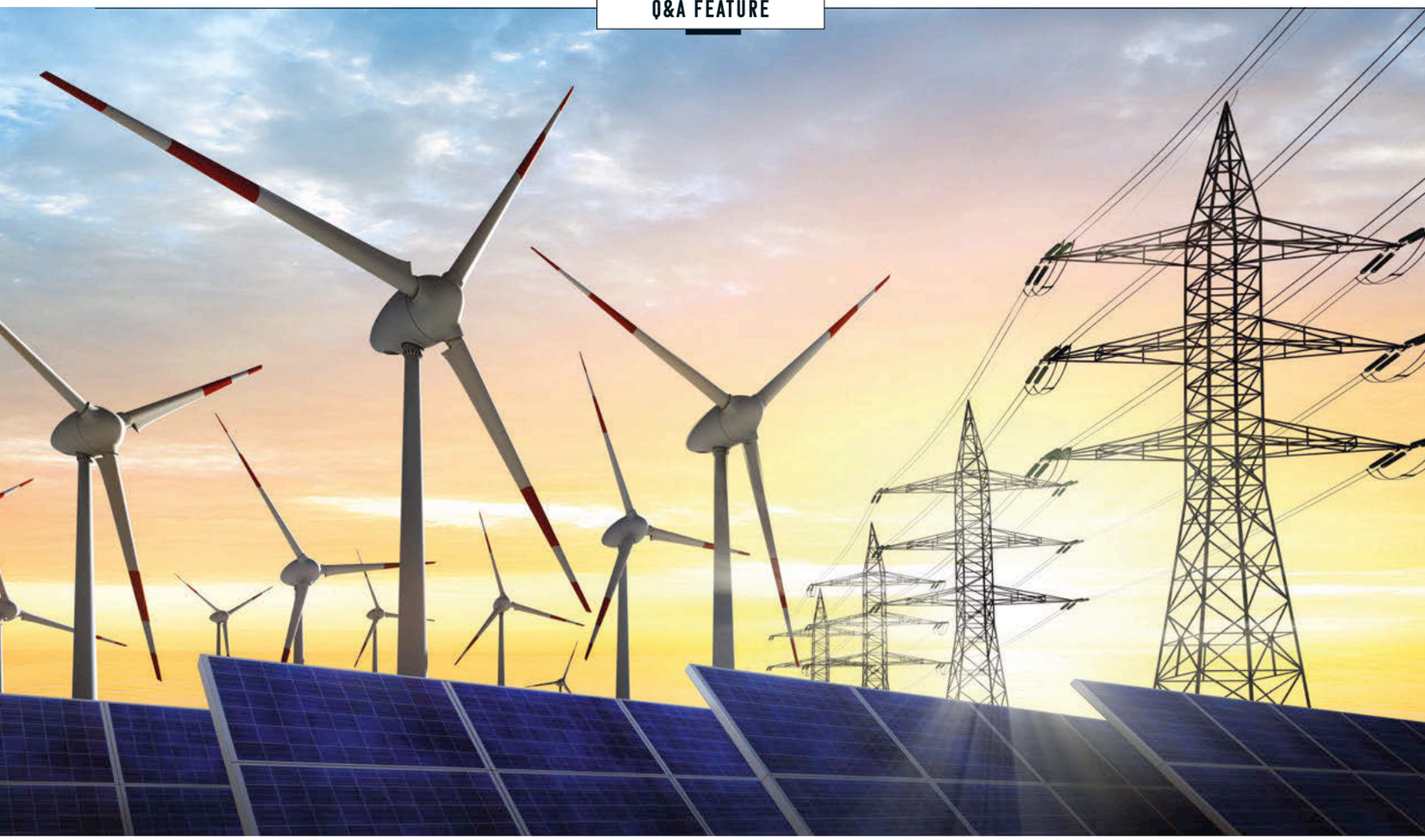
"The idea of being able to design a bike frame as one continuous dynamic unit is just fantastic, from a design standpoint. There's so many different dynamic loads happening at the same time, that to lay out a fibre orientation network that gives us different dynamic qualities at different parts of the frame on different axes, and consider that as one engineered unit, that's a whole new way of thinking in terms of bike frame design."

This would simply not be possible with traditional ways of building carbon fibre bikes, because it is just too expensive to produce moulds to make a prototype and check how it would work. "You just wouldn't take that risk," Stephens said.

Unexpectedly, Stephens has also found that 3D printing is a very good way to make wheels. "One of the other major benefits of the Arevo carbon fibre process is that this is a thermoplastic process, versus traditional carbon fibre which is a thermoset process. What that means practically is the material is much tougher and more impact resistant than traditional carbon fibre bikes. That would be a very risky wheel to make out of traditional carbon fibre."

Stephens believes that this technology could make carbon fibre frames much more affordable. The fact that the Arevo frame forms the basis of the Emery E-bike is more a reflection of the way the bicycle market is currently developing: it was originally made as a conventional bike and is perfectly suited to that type of construction. "It's complete freedom to set aside preconceived notions of how we've just always done things, and consider new forms, new directions, new mechanical concepts, that we otherwise wouldn't be able to explore," he said. "I foresee an opening up of ideas. That's very exciting for me as a designer." THE ENGINEER

POWERED OPTION
The Emery e-bike motor and battery pack sit within Bill Stephens' frame, printed by Arevo; but this was mainly a market development and the bike is viable as a conventional pedal-powered model



Q&A:

Net zero and the challenges ahead for the energy industry

The energy industry has a significant role in achieving net zero greenhouse gas emissions by 2050. The Engineer asked experts how it can be done

JASON FORD REPORTS

The UK's commitment to reduce greenhouse gas emissions to net zero by 2050 is clearly laudable, but the challenges ahead are immense. How can the nation move forward to net zero whilst serving the needs of industry? The Engineer sought the opinions of three experts on the best way forward.

Meet the experts

Andrew Lever, director, the Carbon Trust, an independent partner to global organisations seeking to move toward a more sustainable future

Dr Tim Stone CBA, chairman of the Nuclear Industry Association (NIA), the trade association for the civil nuclear industry in the UK.

Prof Jim Watson, director, UK Energy Research Centre, which conducts interdisciplinary research into sustainable future energy systems

In what ways are net zero ambitions compatible with the demands of large electricity users?

AL: Dramatic growth in renewable electricity supply over the last decade means that net zero ambitions are in reach for large electricity users. The majority of greenhouse gas emissions from electricity consumption can be eliminated by switching from fossil fuel-derived to renewable sources of electricity.

TS: Most large electricity users see the need to support the reduction of emissions to tackle climate change, but cost is a very real business issue. Fossil fuels have historically been cheaper and we have to work hard to bring down costs of replacement low and zero carbon power, as well as developing smarter systems to help big electricity customers manage their demand. Cost reductions are already happening with renewables and we know we can also bring down the costs of nuclear power dramatically.

JW: According to the CCC (Committee on Climate Change), electricity decarbonisation needs to be largely achieved by 2030. Clearly, it will be easier to accommodate the demand of large users of electricity if they maximise investment in energy efficiency. So it isn't just a case of shifting to low or zero carbon generation, but also a case of improving energy efficiency across the economy.

Image credit: peterschreiber.media/stock.adobe.com

> **"THE MAIN CHANGES ARE ABOUT INVESTMENT IN TECHNOLOGIES, INFRASTRUCTURE & OTHER MEASURES TO HELP BALANCE THE SYSTEM"** Prof Jim Watson, UKERC

Which nascent technologies should government be backing in order to help reach - and maintain - net-zero?

AL: In addition to a large-scale move to renewables and ultra-low emission vehicles, reaching net zero will require of greenhouse gas removal options including large-scale forestation, biochar, BECCS (bioenergy with carbon capture and storage), DACCS (direct air capture and carbon storage). Other areas to consider include the use of ammonia for refrigeration purposes. The decarbonisation of heat will require a range of technology solutions including district heating, heat pumps and hydrogen. Whilst many of these technologies are technically mature, further innovation can allow for the full decarbonisation of heat.

TS: A balance needs to be struck, between pushing for breakthroughs in technology, while investing in modern technology that we know works, today. Several smaller nuclear reactor designs are developing well, and the UK leads the world in the development of fusion. Progress is also being made in battery storage and dealing with waste CO2, but we need to make big decisions now on commercially available, proven technology or we will miss the mark.

To have any chance of achieving net zero, we need to be building all the proven low-carbon generation we can, as fast as possible.

JW: Whilst breakthroughs with new technologies might be made in time to meet the 2050 target, this target can be achieved using known technologies. Many of these are already commercially available - or well on their way. So for electricity, the priority should be to continue and expand the deployment incentives for low cost technologies - particularly renewables such as wind & solar - as well as the technologies and infrastructures that will help to balance the electricity system (storage, demand side response, interconnections, and flexible zero carbon generation).

Decentralisation is often cited as a way of reducing emissions from energy, but how realistic is this aim across the UK?

AL: Decentralisation is a necessary part of emissions reduction. We will see a convergence of the electricity, heat and transport sectors, which will result in a more holistic approach to providing solutions. As focus shifts to the decarbonisation of the heat and transport sectors, it becomes evident that many of the decarbonisation solutions are linked to the electricity sector. Electrification of transport is an obvious example. For heat, this could include electrification, bioenergy and hydrogen technologies. To achieve this holistic approach, planning and optimisation of local infrastructure is a key requirement.

TS: While we are seeing larger numbers of smaller 'community' energy projects, we will still need a centralised grid network to support and transport the doubling of electricity production. Decentralisation simply isn't compatible with our projected reliance on interconnected systems. For example, electric vehicle-to-grid schemes will only work if there's a centralised grid to sell your electricity back to. These issues are part of the requirements for the redesigned energy system.

JW: The UK has traditionally had a centralised electricity system - with centralised policies, institutions and governance as well as technologies. I think it would be difficult to achieve a very significant shift towards decentralisation of electricity unless governance, policy, funding and powers are also decentralised further than they are now. Even if this were achieved, there would still be an argument for some centralised infrastructure to balance supply and demand across different locations and regions.

Andrew Lever, director, the Carbon Trust

Dr Tim Stone CBA chairman of the Nuclear Industry Association (NIA)

Prof Jim Watson director, UK Energy Research Centre,

> **"WE NEED TO MAKE BIG DECISIONS NOW ON COMMERCIALLY AVAILABLE, PROVEN TECHNOLOGY"** Dr Tim Stone

What grid-level changes will need to take place to accommodate increasing amounts of electricity generated by renewables?

AL: We are already experiencing innovation in the electricity grid to accommodate increasing amounts of renewable generation. One key trend is the emergence of flexible markets, where Distribution Network Operators contract for flexible demand to manage increasing variability from renewable generation. This potentially negates the need to reinforce the network in some areas and allows the grid to be utilised more efficiently. As decarbonisation of the heat and transport sectors continues, greater convergence of grid planning and local infrastructure planning will be required.

TS: In redesigning the energy system, the changes to the grid will be an output from that design. What is clear already, though, is that the resulting design is highly likely to have balanced mix of renewable and baseload or firm power. Managing the overall system so that there is a high degree of resilience at a sensible cost will require the grid to be properly supported both in terms of its own redundancy (which is arguably too little at the moment) but also in terms of the basis on which supply and demand are allowed to connect to it.

JW: There will need to be some further investment in high voltage grid infrastructure, to enable the further expansion of offshore wind. But the main changes are about investment in technologies, infrastructures and other measures to help balance the system - this means more interconnection with other countries, more storage (though battery storage can only help to balance supply and demand over relatively short timescales so far), demand side response (which is already common in industry) and flexible generation (which needs to be zero carbon - so powered by hydrogen, for example, rather than natural gas). THE ENGINEER

PRODUCT DETAILS
HP's Multi Jet Fusion machines can print parts around the clock

Q&A:

Added attractions

Experts from Stratasys, HP and 3D Systems offer their perspectives on the technologies and trends that are shaping the field of additive manufacturing

ANDREW WADE REPORTS

Additive manufacturing has evolved from a niche tool to a key production process. The Engineer spoke with experts from leading additive companies Stratasys, 3D Systems and HP Inc to find out where the technology currently is and where it's going.

Meet the panel

Philipp Jung (PJ), GM and global head, Vertical Industries & End-to-End Applications, 3D Printing & Digital Manufacturing, HP Inc

Scott Turner (ST), director, Advanced R&D, 3D Systems

Amos Breyfogle (AB), senior application engineer, Stratasys

What are the most exciting trends in additive at the moment?

PJ: Advanced 3D printing is accelerating the shift to digital manufacturing as customers make significant strides on their journey to mass production. And the industry is embracing a new design mindset, as entire organisations realise time, quality and economic advantages. It's about changing how the world designs for manufacturing.

ST: The most exciting developments right now are in additive materials. The key to better and more reliable additive parts is not just from improvements in the technologies themselves, but in materials that really correspond to the needs of manufacturers for end-use part production. This trend has been occurring rapidly for a few years now and you can see 3D printed parts that really hit the mark in terms of toughness, rigidity, and extended use. New materials that stand up to high heat and extreme environments are maturing rapidly, making additive a reality for yet more production-grade parts.

AB: Perhaps one of the most interesting trends is the impact of additive manufacturing on supply chain issues. We've seen more and more companies turn to additive manufacturing because it offers true 'on-demand' production, close to the point of consumption. For manufacturers, this is a game-changer, with missing or broken parts produced in only a few hours. In aerospace, this can overhaul the traditional maintenance, repair and operations supply chain. Our customer Airbus is a great example. To meet the production delivery deadlines of its A350 XWB aircraft, the company leveraged our FDM technology to manufacture over 1000 parts that are flying today.

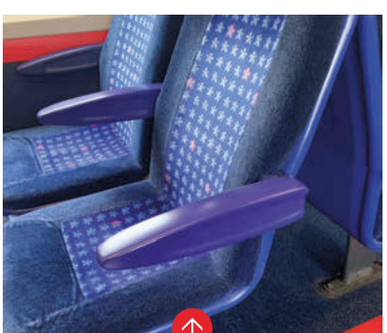
How is the technology being adopted across different sectors?

ST: For every sector, adoption of additive

starts with a single success that forms the confidence to trust AM for their products. For almost every industry, AM has become the "best practice" for prototyping efforts. These prototypes are often the genesis of how a company suddenly sees the path forward to use additive for better performance and get to market faster than ever before. All sectors are in a race to achieve that success and new materials for additive enable that. The technology has so many strengths in complexity and speed in which things can be made, I believe it will become the dominant manufacturing method for many industries.

AB: If we take the manufacturing industry – aerospace, automotive and mobility are key vertical sectors that fall within it and which demonstrate the end-to-end way in which 3D printing/additive manufacturing is being deployed. For example, in each of these sectors, design engineers will be accessing technologies such as PolyJet to conceptualise and develop ultra-realistic functional prototype models. The production lines of these same companies will likely be harnessing other, more industrial-based technologies, such as FDM, and via durable thermoplastics be producing production-line tooling such as jigs & fixtures. The same technology could then be deployed to produce low-volume production parts that adhere to specific industry-standards and that ultimately are used in cars, trains and aircraft.

PJ: HP is embracing an end-to-end applications approach, focusing our 3D printing efforts on four key verticals—automotive, footwear, dental and medical. As part of that, HP is offering advanced 3D printing solutions to help customers in these key markets develop breakthrough applications, speed time to market and accelerate their journey to digital manufacturing. In the automotive sector, HP is working with some giants including Volkswagen, BMW and Jaguar Land Rover. And in footwear, HP's 3D printing technology powers the FitStation platform for the production of customised 3D printed insoles.



PRODUCT DETAILS
Train armrests no longer in production were 3D printed by Stratasys

> **"ADVANCED 3D PRINTING IS ACCELERATING THE SHIFT TO DIGITAL MANUFACTURING"** **Philipp Jung, HP**

Can you give us an interesting customer success story?

PJ: I am really excited about SmileDirectClub, the pioneer of teledentistry and market leader in doctor-directed, remote clear aligner therapy, and how HP is powering their extraordinary growth. SmileDirectClub is now the largest producer of Multi Jet Fusion 3D printed parts in the country, with 49 HP Jet Fusion 4210 systems running 24x7, producing more than 50,000 unique mouth moulds each day. That's nearly 20 million custom parts in the next year alone!

AB: A good example is our collaboration with leading train leasing company, Angel Trains; engineering consultancy, DB ESG; and train operator, Chiltern Railways. This saw us recently join forces to trial the first 3D printed parts ever deployed within an in-service passenger train in the UK. These parts include four passenger armrests and seven grab handles. Using 3D printing, Angel Trains and DB ESG were able to replace a small number of obsolete parts, producing the exact quantity they needed at a fraction of the time and cost of traditional methods.

ST: In 2015, orthopaedic device manufacturer, NuVasive, recognised the opportunity that additive delivers for production of complex and optimised parts, and how that could open new business revenues. To help design and manufacture minimally invasive spine solutions, they turned to 3D Systems. Working in collaboration, both teams pioneered a new implant line that leverages the potential of metal additive manufacturing. The result was that NuVasive went from design-to-market in just over one year with the launch of Modulus.

Philipp Jung GM and global head, Vertical Industries & End-to-End Applications, 3D Printing & Digital Manufacturing, HP Inc.

Scott Turner director, Advanced R&D, 3D Systems

Amos Breyfogle senior application engineer, Stratasys

How do you see additive evolving in the coming years?

AB: As is the case in many industries, digitalisation is transforming manufacturing processes. Systems development and better materials are always at the forefront of the progress in the additive manufacturing industry. We also expect software and networking to play a greater role in the coming years, helping companies decentralise production and access digital inventory on-demand. There is no doubt that the technology will get faster, cheaper and more accessible, with R&D teams across the world constantly pushing the technology to be better.

PJ: Automated assembly will arrive, with industries seamlessly integrating multi-part assemblies including combinations of both 3D printed metal and plastic parts. The consumer health sector will fuel digital manufacturing growth and adoption, as footwear, eyewear and orthodontics applications rapidly adopt 3D printing technologies. Automakers will continue to unlock the capabilities of metal and plastic 3D printing systems to accelerate electric vehicle production. And data and software will continue to become even more important and become the true backbone of digital manufacturing.

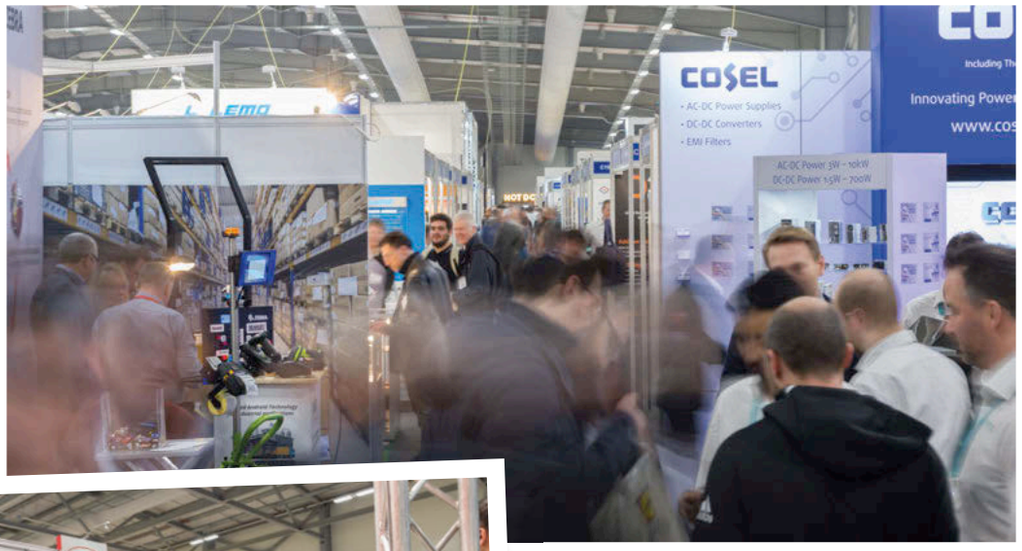
ST: We're entering a new era of digitally-derived products. From an industrial perspective, biomedical and aerospace applications are seeing the strongest development and honestly have not yet scratched the surface in what I think will be possible over the next decade. Research on 3D printed organs is evolving quickly. Lighter and more effective parts made by additive for airplanes, rockets and satellites are becoming real and are in flight. 3D printed 'dentures in a day' just received FDA certification. It's going to be incredible to see and I'm excited to be a part of this evolution. THE ENGINEER

ALL BASES COVERED

Southern Manufacturing & Electronics 2020 on course for record numbers

Southern Manufacturing & Electronics returns to Farnborough from February 11th to 13th 2020. The exhibition, the longest running annual engineering exhibition in the UK, is already close to achieving full occupancy of the 20,000m² Farnborough International Exhibition Centre and the organisers are confident of exceeding the 8,700 individual visitors achieved in 2019.

As in previous years, the 2020 event will host an impressively broad exhibitor list spanning the complete range of engineering activity, from high-tech machine tools and automation to components and subcontract services. Firms from all over the UK will be participating, together with a significant number of off-shore exhibitors from across Europe, Asia and the Far East.



The show is divided approximately equally between manufacturing and electronics. In the former, the Machinery area is one of the most widely visited, providing visitors with the chance to look at the latest offerings from a selection of international vendors. Firms exhibiting for 2020 include Bystronic, C. Dugard, Haas Automation, Hurco, Laser Lines, Matsuura Machinery, TRUMPF, XYZ Machine Tools and Yamazaki Mazak. Other well known names include Mitutoyo, AMF Andreas Maier, Faro, MecWash, Brady, Henkel, Bruderer, Blum Novotest and Roemheld. Engineering service providers exhibiting include Orbital Fabrications, Perfect Bore, Industrial Plastic Fabrications, Twickenham Plating, Washington Metalwork, Southern Springs & Pressings, MJ Allen alongside many others.

The electronics aspect offers an abundance of production, automation and test systems from firms such as Blundell Production Equipment, Mycronic, AdoptSMT, ASM Assembly Systems and PACE Europe amongst others. Component vendors include ESI Technology, Wurth Electronics, TDK Lambda, Luso Electronics, Easby Electronics - the largest single exhibitor at the show - and Cosel Europe. The scores of service suppliers exhibiting include full contract manufacturing from companies such as JJS Manufacturing and Heber Electronics, to PCB production from European Circuits and Shenzen X-Mulong. The free seminar programme is another tremendously popular feature of the show. Two programmes run in tandem in two theatres over three days, devoted to manufacturing and electronics respectively. Topics tackled include technology, innovation, advanced materials, business management, marketing and a review of ongoing industrial law and regulations. Free access to this variety of high-calibre industry and business knowledge is another powerful reason for manufacturing professionals to attend the exhibition.

Following last year's successful cooperation, Southern Manufacturing & Electronics 2020 will once more be partnering with the Farnborough Aerospace Consortium, alongside national bodies including Composites UK, NetComposites, the Confederation of British Metalforming, the GTMA and the British Gear Association. Also taking part this year is Locate in Kent, an organisation offering a wide range of services and assistance to firms looking to locate in the region.

Farnborough International Conference and Exhibition Centre offers complimentary car parking for 3,500 vehicles and is well-served by road and public transport links. A regular free shuttle bus service operates from both of Farnborough's mainline railway stations directly to the exhibition. The venue itself provides a high standard of facilities including a complimentary WiFi service in the foyer area as well as high quality catering outlets.

Southern Manufacturing & Electronics 2020 opens from February 11th to 13th. Admission to the exhibition is free of charge. More information as well as a full list of exhibitors can be found at www.industrysouth.co.uk . THE ENGINEER

SOUTHERN 20 Manufacturing & Electronics

Incorporating The Subcontract Engineering Exhibition

AUTOAERO

FARNBOROUGH • 11-13 FEBRUARY 2020

FREE SEMINARS

FREE PARKING

FARNBOROUGH | Hants | GU14 6TQ

11th | 12th | 13th FEBRUARY 9.30am - 4.30pm *(3.30pm close Thurs)*

Where Industry and Innovation converge

Meet over 800 national and international suppliers at the Farnborough International Exhibition & Conference Centre this February at Southern Manufacturing & Electronics (inc AutoAero) 2020. See live demonstrations and new product launches of machine tools & tooling, electronics, factory & process automation, packaging & handling, labeling & marking, test & measurement, materials & adhesives, rapid prototyping, ICT, drives & controls and laboratory equipment.

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

The exhibition is **free** to attend, **free** to park and easy to get to. Doors open at 9.30am on Tuesday 11th February.

OIL & GAS
DEFENCE
FOOD & DRINK
AUTOSPORT
MARINE
AEROSPACE
PACKAGING
LOGISTICS
ELECTRONICS
AUTOMATION
ROBOTICS
MEDICAL
COMPOSITES
SPACE ENGINEERING
RAIL
TRANSPORTATION

▷ PRE-REGISTER TODAY
for your Fast Track Entry Badge, Preview Magazine and Event Catalogue at
www.industrysouth.co.uk

SOUTHERN MANUFACTURING & ELECTRONICS
is an ETES event organised by European Trade & Exhibition Services Ltd
Tel 01784 880890 · email philv@etes.co.uk

etes Regional Manufacturing Exhibitions

Supported by: fac · CBM Confederation of British Metalforming · Composites UK Trade Association · BGA British Gear Association · gtma · NetComposites

HILDA LYON: AERONAUTICAL PIONEER

One of the most important women engineers of the 20th century, Hilda Lyon's name lives on in her eponymous 'Lyon Shape' streamline design used in submarines and airships.

WRITTEN BY NICK SMITH

On 26th June 2019 the small Yorkshire town of Market Weighton played host to a blue plaque unveiling commemorating the life of Hilda Lyon, a shopkeeper's daughter who was to become one of the most influential women engineers of the 20th century. The unusually long citation narrative that follows her name, post-nominal letters and general description of her as 'aeronautical engineer,' credits her with helping to design the R101 airship, inventing the 'Lyon Shape' and being the first female recipient of the Royal Aeronautical Society's R38 Memorial Prize. Beneath this list of accolades, the blue plaque (located at her father's shop in the town's High Street) reads: 'Her work is still used for stability software and submarine design.' For Lyon's relatives – many had crossed the Atlantic for the ceremony – this recognition of the British engineer, described by Flying magazine in 1934 as "the classic authority on the subject of stresses in transverse frames," was both overdue and appreciated.

Hilda Margaret Lyon was born in Market Weighton in 1896 in the final decade of Queen Victoria's reign. It was the year of the introduction of the x-ray machine, the first ever scientific paper on the sensitivity of the global climate to atmospheric carbon dioxide, Henry Ford's first car 'the Quadricycle' and the launch of the legendary French motion picture company Pathé. As the 19th century drew to a close, the Anglo-German naval arms race spawned by the creation of the German Reich after the Franco-Prussian War had already planted the seeds of the First World War. But for Lyon, who came from a family of shopkeepers and farmers in the relative tranquillity of a remote northern town, global events played little part in her early years. In fact, she spent most of the Great War at Newnham College, University of Cambridge, from which she obtained a BA in mathematics in 1918, styled 'title of degree' because Cambridge wasn't to award full degrees to women until 1948.

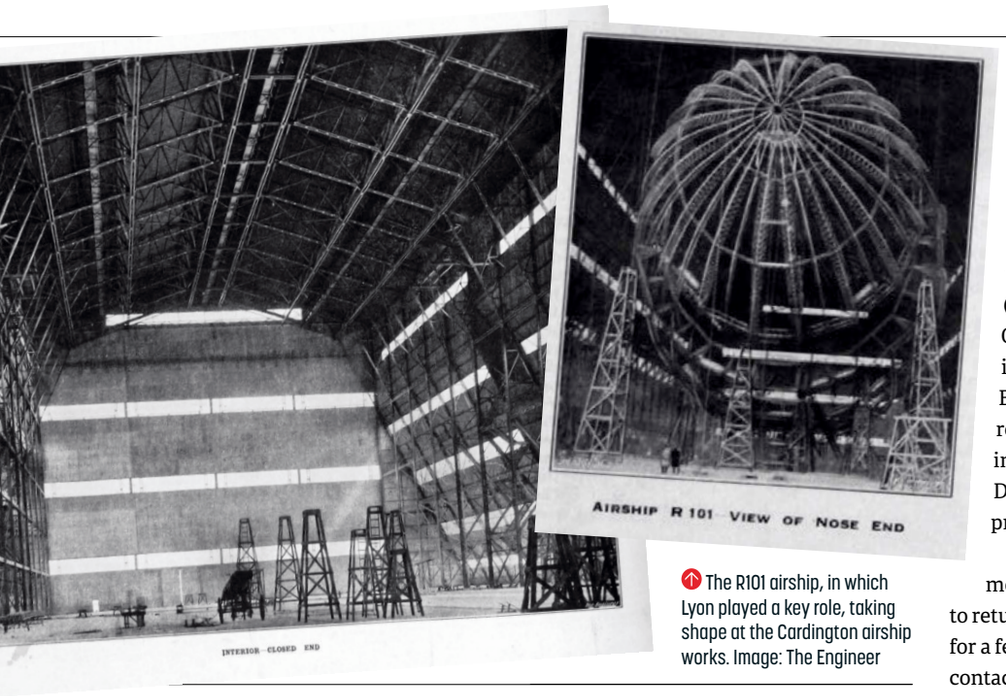
HILDA LYON 1896 - 1946

After graduating, Lyon took an Air Ministry course in aeroplane stress-analysis that in turn led to her taking a job as a technical assistant. Realising this position offered neither further promotion or responsibility 'for a woman mathematician' she resigned from the ministry and took a six-week sabbatical in Switzerland. It's not easy to establish exactly why she went on this trip with her sister, but it provides insight into her propensity for world travel that was to be a feature of her distinguished career in both academia and industry. It is, however, a matter of record that on her return to the UK later in 1918 she worked for a number of British manufacturers, including a stint at the Siddeley-Deasy Motor Company as a technical assistant, before moving on to aircraft builder Parnall & Co in 1920 (where she probably worked on Puffin, Possum, Pixie and Perch aircraft). During1922, Lyon was admitted as an Associate Fellow of the Royal Aeronautical Society, and by the mid-1920s she found herself on the technical staff at the Royal Airship Works in Cardington as part of a team developing the R101 minimum-drag hull, rigid airship.

After the end of the First World War, the UK government had recognised the potential for airships as a method of modernising communications with Britain's overseas colonies and for transporting troops. With a length of 731ft, the R101 was the largest flying machine ever built and was to remain so until the introduction of the Hindenburg seven years later. Prior to its first flight, Lyon wrote to her brother: "When are you coming to see the R101? Hope that it's a north wind when I get my first flight so that I can persuade them to fly over Market Weighton though it looks like rubbing it in too much to the Howden people." The 'Howden people' Lyon refers to was the Yorkshire-based commercial manufacturer of the R100 airship that was pitched in direct competition to the R101. According to Lyon's relative Rosi Lambkin, 'the Air Ministry were

Photo from the Enid Greenwood archives, with consent of the family".

READ MORE
Late, Great Engineers at
www.theengineer.co.uk

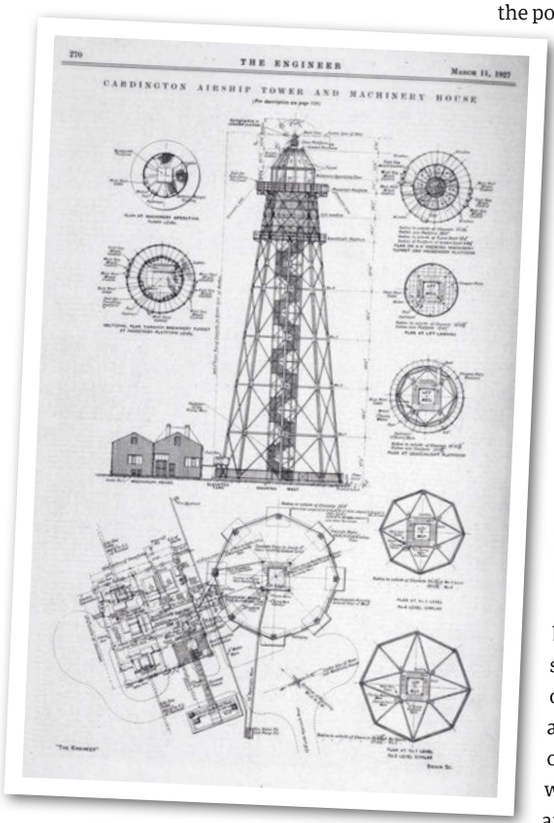


The R101 airship, in which Lyon played a key role, taking shape at the Cardington airship works. Image: The Engineer

desperate for a flight to India to be undertaken, despite the lack of full endurance and speed trials.' As with the more famous Hindenburg, the R101 met with disaster, crashing in northern France during its maiden overseas Karachi-bound voyage on 5th October 1930, killing 48 of the 54 people on board. The government responded by shelving the entire airship programme and had the remaining R100 broken up.

Although Lyon had flown on the R101 maiden test flight – writing to a cousin to say how she'd 'enjoyed it immensely'– she was not on board that fateful flight to India, having left her job at Cardington shortly before to take up studies across the Atlantic at the Massachusetts Institute of Technology. At MIT she worked with experimental wind tunnels and engineering laboratories, where her research identified the optimum shape for an airship, which became known as the 'Lyon Shape' (a term that is still current in the US) and was also incorporated into the 1953-commissioned American submarine USS Albacore that had a streamlined hull specifically designed for underwater running, as well as subsequent American submarines and designs by other overseas manufacturers. Lyon also took the opportunity at MIT to submit her master's thesis – 'The Effect of Turbulence on the Drag of Airship Models' – that she'd completed in her spare time while still at the Air Ministry.

> **"I HAVE JUST HAD MY FIRST FLIGHT AND ENJOYED IT IMMENSELY... IT WAS QUITE A SHORT JOY RIDE."**
> HILDA LYON



Archive illustration from The Engineer showing the Cardington airship tower and machinery house

On completion of her stay at MIT, Lyon departed America on the second of her traveling scholarships for Göttingen in Germany, where she conducted research at the Kaiser Wilhelm Gesellschaft für Strömungsforschung (now the Max Planck Institute for Dynamics and Self-Organization) under the German scientist and pioneer in the field of aeronautical engineering Ludwig Prandtl. Based on its classic tear-drop 'Albacore hull' profile, it remains possible that Lyon's work at Göttingen may have influenced the design of the German midget speed attack Delphin-Class ('dolphin') submarine, of which only three prototypes were ever built.

Lyon's time at Göttingen ended prematurely when her mother became ill, leaving her with few options other than to return to Yorkshire in order to care for her. Perhaps unusually for a female scientist at the time, Lyon was able to maintain contact with her field, while keeping up with her research into aerostatic flutter and elastic blades by using university libraries in Hull and Leeds and by visiting the National Physical Laboratory and the Royal Aircraft Establishment (RAE). What might under normal circumstances have been a career-ending hiatus was avoided due to the foresight of her former supervisors at the Royal Aircraft Establishment who, realising the significance of her expertise, encouraged Lyon to continue her work from home. In the two years prior to her mother's death in 1934, Lyon was able to publish two scientific papers on streamlining and boundary layer effects, followed by a further two papers in 1935, after which the RAE created the post of Principal Scientific Officer in its aerodynamics department at Farnborough to open the door for her full-time return to work in 1937. She would also serve on the Aeronautical Research Council and sat on the RAE Education Committee where she showed a keen interest in apprentice training.

As fellow RAE engineer Frances Bradfield noted in her obituary of Lyon, "a four-year break would have ended most women's work." Instead, Lyon published scientific research papers frequently for the rest of her career (as well as posthumously), while her war work included involvement in stability analysis for the Hawker Hurricane single-seat fighter aircraft that was to play a pivotal part in the Battle of Britain in 1940, as well as seeing combat in all major theatres of the Second World War. Her 1942 paper – "A theoretical analysis of longitudinal dynamic stability in gliding flight" – is widely held as a classic and is to this day cited in the world of streamlining and boundary layers.

Lyon died in Surrey in 1946 at the age of 50 and is buried in Market Weighton. While little is known of how she died (other than it appears to have followed a medical operation), what is clear is how deeply her loss to the aeronautical engineering community was felt. Director of the RAE, W G Perrin wrote of Lyon after her death: "She won a real place in our affections., and by her painstaking and steady effort she claimed the respect of everyone who was privileged to work with her. She will be missed by all her friends both at the RAE and in industry and her death is a loss that will be felt throughout the scientific world." THE ENGINEER

JANUARY 1931

Grain Power

The Engineer reports on a key innovation from the food processing industry

WRITTEN BY JASON FORD

The farm of the future (subject of this issue's cover story, p16) promises precision delivery of nutrients to individual plants, which will improve the farmer's bottom line and increase yields.

The use of AI and machine vision have the potential to revolutionise the farming industry once more, making farming more productive and simultaneously improving the condition of fields in which crops are grown.

But growing a crop is just the start of a chain of events that sees a raw material – be it wheat, barley or spelt – move from the farm and into the hands of processors and manufacturers.

The Engineer took a closer look at an intermediate stage of food processing in 1931 when it reported on a pneumatic grain elevator installed on the instructions of a certain Mr A Binns, M.Inst.C.E, M.I.Mech.E, the Engineer to the Port of London Authority.

The pneumatic 'Thomas Wiles' grain elevator was designed and built by a company founded in Manchester by Henry Simon, an engineering polymath whose numerous achievements include the introduction of roller milling, which saw improvements in three key areas of flour processing, namely grinding, purifying and dressing.

Simon passed away in 1899 but his legacy continues with over 3400 staff operating globally to deliver milling expertise accumulated during the company's 141-year history. Another facet of the Stockport headquartered company is handling, and in 1931 Henry Simon Ltd, as it was known, delivered a grain elevator capable of handling 110 tons of grain per hour.

The elevator was specially built to meet the demand of the grain trade in the Authority's docks, and an outstanding feature of the design, said *The Engineer*, was the range of steamers it would serve, embracing the smaller tramp steamer to the large liners of the Atlantic Transport Company's 'Minnewaska' and 'Minnetonka' vessels, which were the largest ships using the Port of London at the time.

The overall length and breadth of the pontoon was 82ft and 35ft respectively. The breadth at the bottom was 32ft 6in and it had a moulded depth of 12ft 6in.

"The pontoon is divided into five compartments," said *The Engineer*. "Forward there is a storeroom, which is separated by a water-tight bulkhead from the compartments in which are placed the engines and exhausting pumps, the elevating machinery, and the boiler respectively.

"At the after part of the pontoon, there are quarters for the crew, and amidships there are an engineer's cabin and a dynamo-room. The corners of the pontoon at either end are arranged with water-tight compartments for water ballast."

The twin engine-driven pumps which produced the vacuum for lifting the grain and depositing it into the grain receiver were, said *The Engineer*, of the 'Simon' special type, with a cylinder diameter of 45 1/2in and a stroke of 16in. that were coupled direct to the engine.

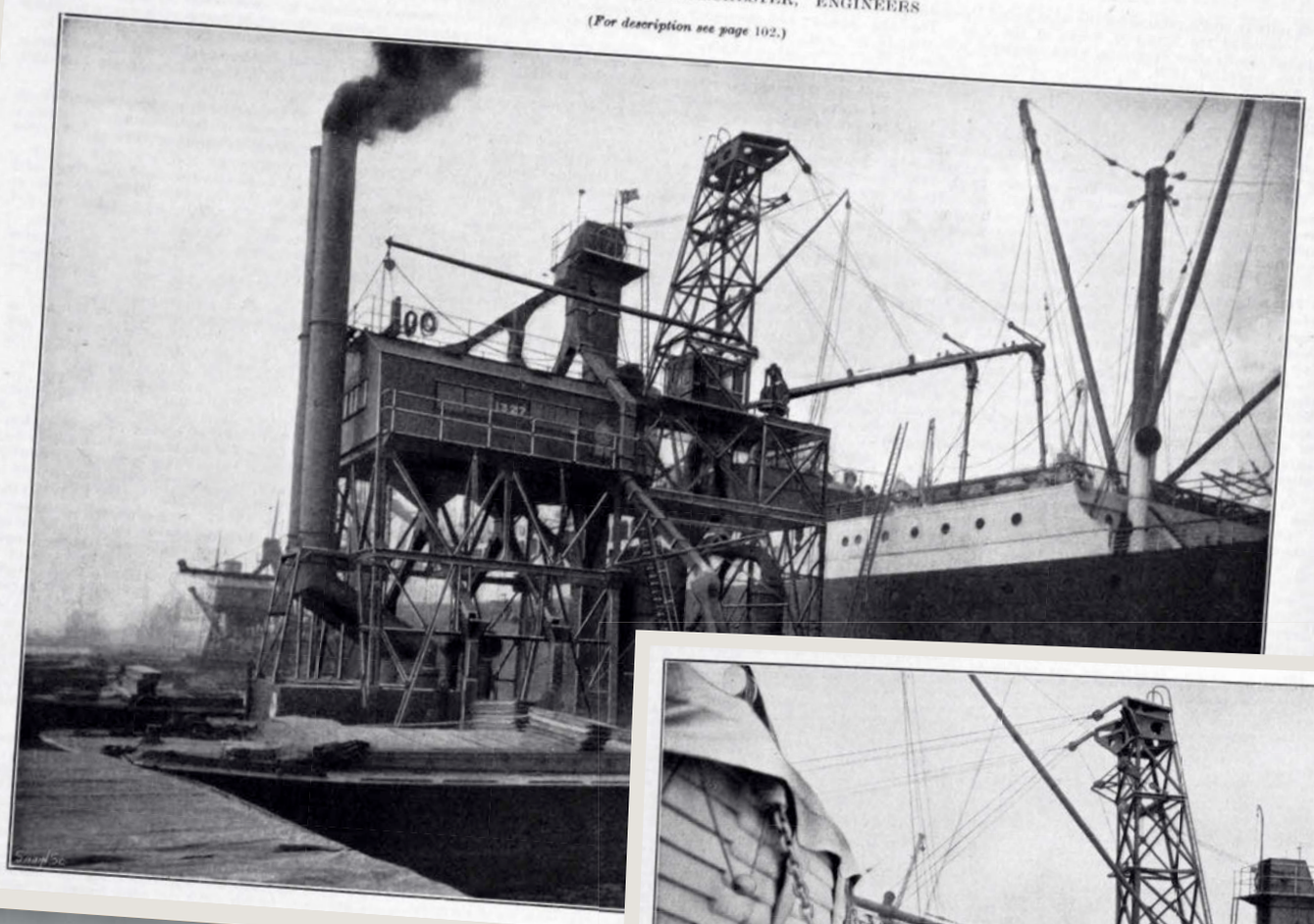
"A feature of the valve design is the arrangement of the valves at the outsides of the cylinders, which gives easy access for examination and cleaning, a special platform to the cylinders being provided," our correspondent wrote. "The pistons are furnished with special rings and are dry lubricated. Between the pumps, and the receiver there are two cyclones for removing the dust, and there is a release valve which can be operated from the engine room, the function of which is to break the vacuum in case of emergency. At each cyclone there is a motor-driven dust seal, which removes the dust without breaking the vacuum."

The grain receiver itself consisted of a large circular steel tank built in sections and attached to the superstructure of the pontoon by a steel ring with cast iron supporting feet. The bucket elevator was enclosed in a weather-tight casing, supported on the floor of the pontoon, and carried high enough to deliver the grain either to the weighing room or directly over-side. The automatic weighing plant was accommodated in a steel-braced weigh house, having steel-framed windows and

A FLOATING PNEUMATIC GRAIN ELEVATOR

HENRY SIMON, LTD., MANCHESTER, ENGINEERS

(For description see page 102.)



wooden doors, with the necessary access platforms and ladders, said *The Engineer*.

"Compensation for the grain in transit at the cut-off of the feed gate is effected by the "Reform" patented compensating device, which permits of the amount in transit being ascertained and compensated for, positively upon the first weightment," our correspondent observed. "A feed gate-closing handle, which is conveniently arranged on the side frame, enables the machine to be stopped instantly during any part of the operation. This fitting, used in conjunction with the residue weighing steelyard, enables pre-determined parcels of grain to be weighed off with extreme accuracy. A supplementary locking catch is also fitted, so that the machine can be stopped at the end of any weightment." .THE ENGINEER

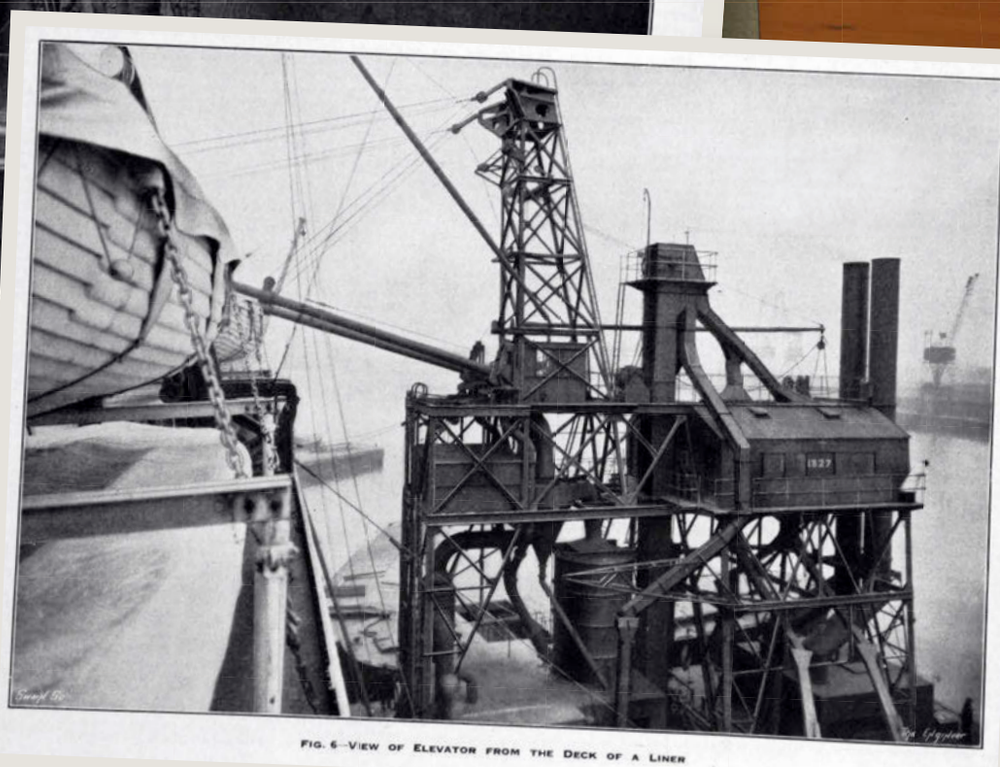


FIG. 6—VIEW OF ELEVATOR FROM THE DECK OF A LINER

Making a meal of it

The grain elevator at the Port of London docks could serve vessels from tramp steamers up to large liners

GARETH L. POWELL

Dress to impress

Exoskeletons and implantable electronics might develop in useful, exciting or terrifying directions

Last month's issue of *The Engineer* carried a story about a tetraplegic man who has taken his first steps in a laboratory thanks to an exoskeleton suit developed by biomedical research centre Clinatec and the University of Grenoble. On the same page [p. 10], it also mentioned that Birmingham University researchers have developed a new self-healing polymer-based hydrogel that can be used to print soft biomaterials to repair defects in the body.

Mention exoskeletons to any science fiction fan, and they will immediately think of Ripley's clunky yellow power loader from the 1986 film Aliens—a kind of wearable JCB that gets repurposed in the finale as a suit of armour. But might these new developments offer us the opportunity to do something a little more radical than reinvent the fork-lift truck?

While both the US and Russia are developing military exoskeletons to improve the strength, speed and stamina of their soldiers, these essentially amount to a series of struts and motors strapped to the limbs of the individual. Add in one of the jet packs currently also under development, and we have the beginnings of Tony Stark's Iron Man suit.

However, if these exoskeletons can be controlled by wireless electrodes in the brain (as they are in the case of the man who just took his first steps in the prototype mentioned at the top of this article), it begs the question: do we need the human present at all?

If we can print biomaterials and a workable skeleton, could we combine them to form synthetic bodies controlled by a living operator some distance away? It could certainly be one solution to reducing air travel. Instead of flying across the Atlantic, you would hook yourself into an artificial body designed to resemble you, and attend your business meeting, publicity junket or political summit remotely—with the advantage of being able to shake hands and physically interact with the other attendees.

Another application, assuming the haptic feedback from the synthetic fingers could be made fine enough to enable a genuine sense of touch and dexterity, could be in the construction of disposable bodies for bomb disposal experts, or clean-up crews in radioactive or otherwise toxic environments—maybe even construction crews on the seabed. Imagine being able to walk around the wreck of the *Titanic* or explore the depths of a deep ocean trench.

As the technology matures and the interface between the machine and the nervous system gets better, these remote bodies could be used for more intimate purposes, such as maintaining a long-distance sexual relationship.

And who says we even have to stick with making them human? Perhaps you could roam the forests of India in the body of a tiger or ride the Rocky mountain updrafts as an eagle. Maybe we could even replace the bulls at Pamplona with synthetic bulls controlled by gamers from around the globe, allowing thrill seekers to brave a trampling while sparing actual animals the stress of the event—and who wouldn't want to remotely gore a few tourists, just for fun?

> "MAYBE WE COULD REPLACE THE BULLS AT PAMPLONA WITH SYNTHETIC BULLS CONTROLLED BY GAMERS TO SPARE THE ANIMALS STRESS"

James Thew/stock.adobe.com

On a more serious note, might it be possible to create tiny creatures that could allow surgeons to remotely explore the inner workings of the human body in order to diagnose and combat tumours and other disorders—although the cognitive dissonance of 'inhabiting' such a creature might take a bit of getting used to!

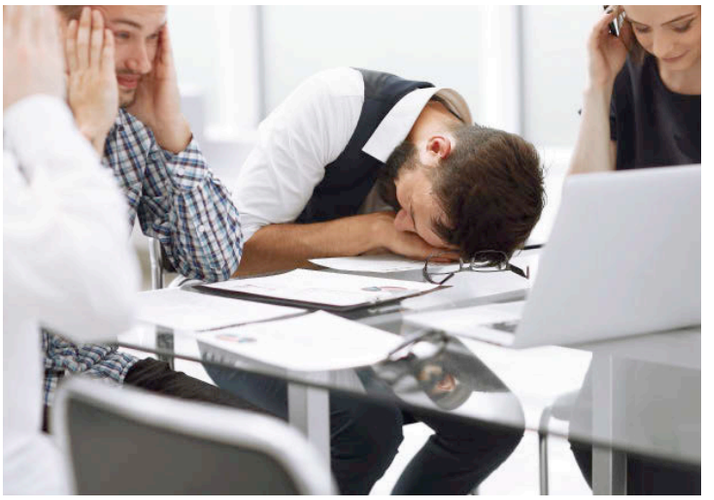
William Gibson famously wrote that, "The street finds its own use for things." The same goes for the military. Any technology allowing a doctor to enter and fix a human body could also be used to allow an assassin to infiltrate and wreck one from the inside. Snip a couple of blood vessels in the brain, the results will resemble a stroke, and your opponent will have died from apparently natural causes.

So far, all these speculations have been earthbound. As a science fiction writer, I have to look higher and think weirder. Yes, we could have remote astronauts walking barefoot across the Sea of Tranquillity, but that seems rather tame. Instead, picture jacking your consciousness into a balloon-like creature riding the winds of Jupiter, or maybe a swarm of tardigrades on the surface of Titan.

Thinking bigger still, we could print a whale-like organism, equip it with fusion motors, and set it off into interstellar space. The 'lag' between operator and ship would gradually grow unmanageable as distance increases—by the time it reached our nearest star, a signal from Earth would take four years to reach it, and another four years to return—it would still be theoretically possible to access the remote and experience what it experienced four years previously; ideal if you wanted to feel you were gazing on an alien star system with your own eyes! THE ENGINEER

DEALING WITH THE DESIGN DABBLERS

Design by committee can be a frustrating process, but taking the time to educate non-specialist colleagues about the engineering mindset can help ease the pain, writes our anonymous blogger.



Things seem to be going pretty well at the latest place of employment but, as with anywhere, there are unique challenges to be dealt with. Without wishing to give too much away there is a slightly odd relationship with the different departments here, nothing to cause friction generally but one where it all feels a little "odd." This is probably best illustrated by a recent exchange regarding a part that I've designed. The drawing was sent off for quote for manufacture and when the price came back it was a tad expensive. I was rung by the person dealing with the procurement and in a very matter of fact way informed of this, then asked if I could "make it from another material?" Not as a general query but literally "X is expensive, can it be made from Y?"

Having been pounced upon when using levity in the past with regard to such situations let me state that I, of course, have no problem with questions being asked. Better still though would be to simply feed the quote back to me. If nothing else, in this case I had created the design at the request of another department so in fact it was this third party's budget and they had to make the decision on whether to proceed or not. However the problem lies deeper with either a recognised or unwitting assumption regarding process and expertise. As an engineer I had weighed up the design specification, the particular requirements of the component and the cost, then selected the material accordingly. Not only was this far removed from being an arbitrary decision by myself but the alternative suggestion completely compromised a key part of the design brief.

The problem, I think, stems from a perception that engineering isn't that difficult and others outside of our own profession can dabble without causing problems. Funnily enough it was something I noticed regarding a senior person at my last place of permanent employ. Whereas it was incredibly frustrating then, in this latest case I was merely incredulously amused. There is of course every opportunity for this to go in the opposite direction but personally I would never dream of, for instance, saying to the chef in the canteen "Cream's rather expensive, can't you use water as a filling in the doughnut instead?" I have an appreciation and respect for the fact that they do something I cannot, or certainly something I cannot do anywhere near as well as they can.

So what lies behind this and / or how can it be avoided in the future? Certainly anyone can have a bright idea, either generally or about a particular problem that needs to be resolved but unless they are equipped to understand the challenges with implementing that idea in a viable way, its not likely to get very far.

I do think this is something we can actively help to tackle though. In this case I pointed out that the material choice was key and that savings could be found through less drastic measures. True, other parts of the design brief would have to be compromised but these were criteria that come under the "would like to have" banner, and which could be shed as part of the normal path of development and refinement. Hopefully taking the time to explain such matters will start a process where the eyes of others are opened to the fact that there are usually a number of potential solutions to any problem, not just the most obvious, and equally probably any number of factors at play they are unaware of. Perhaps trying to encourage more cross-functional meetings throughout the project so they have greater visibility overall could be a good long-term plan? Arming them with a deeper understanding throughout could, I think, work very well in improving the situation. Working closer to enable efficient decision making rather than building walls to keep others out.

However that would mean breaking another notable aspect of the company culture: randomly not turning up to meetings. The work of the Secret Engineer in righting wrongs, it would appear, is never done. THE ENGINEER

Image credit: yurolaitsalbert/stoc.adobe.com

Over 100 years invested in the UK's future

Leonardo has over 100 years of history at the leading edge of advanced design and manufacturing in the UK.

Over 7,000 highly-skilled employees and a vast network of suppliers and partners design and develop industry-leading aircraft, electronics, space, defence and security systems for UK and export customers, worldwide.

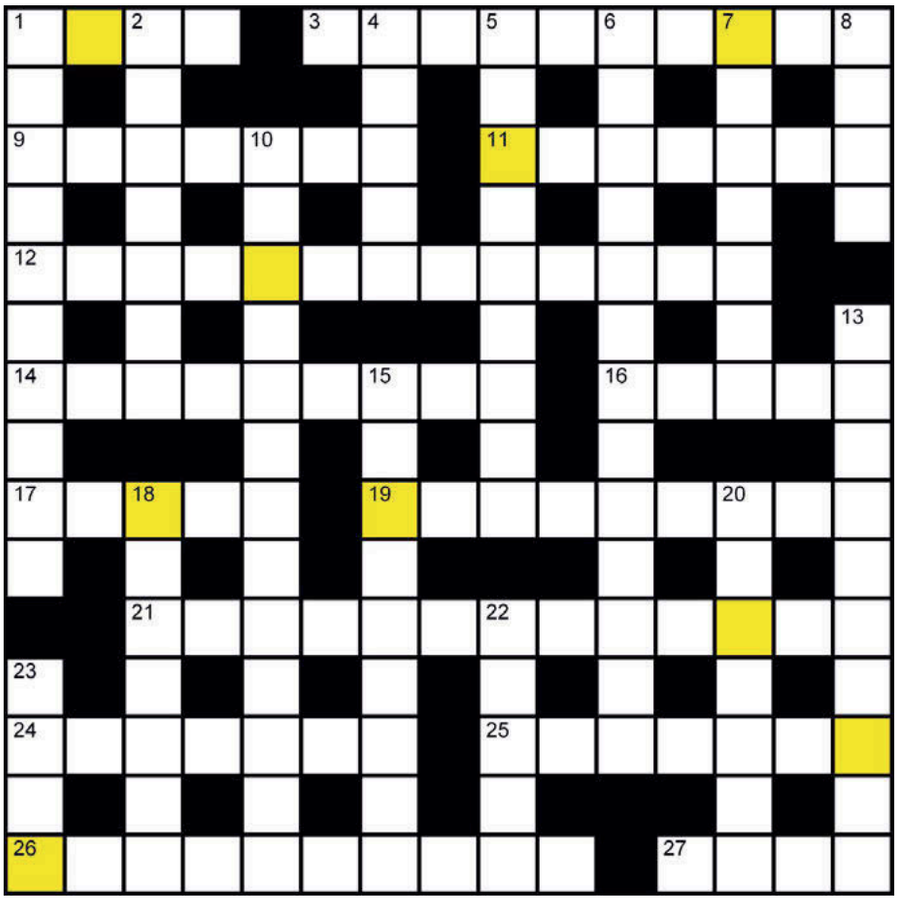
Inspired by the vision, curiosity and creativity of the great master inventor - Leonardo is designing the technology of tomorrow.

leonardocompany.com

Helicopters | Aeronautics | Electronics, Defence & Security Systems | Space

LEONARDO

CROSSWORD



Across

1 Safety device in an electrical circuit (4)
3 Having parts that slide one within another (10)
9 Flowing in drops (7)
11 Makes certain of (7)
12 Study of fluids in motion (13)
14 Article that is fragile (9)
16 Large stringed instrument (5)
17 Substance that causes recuperation from an acute disease (5)
19 Gaining with effort (9)
21 Variable that has zero as its limit (13)
24 Pigment mixed with egg yolk (7)
25 Medieval steel helmet (7)
26 Uttered with a spitting sound (10)
27 Transparent optical device (4)

Down

1 Be good enough for what is required (3,3,4)
2 Piece of wood that has been turned on a lathe (7)
4 Dark mineral used as an abrasive (5)
5 Current Queen of England (9)
6 Negative feature of the credit crunch (4,9)
7 Handheld collapsible source of shade (7)
8 Object formed by a mould (4)
10 Secondary or incidental outcome (5-2,6)
13 Changes from a liquid to a thickened state (10)
15 Clear and sudden understanding of a complex situation (5,4)
18 Caused by an earthquake or earth vibration (7)
20 Unusually great in size (7)
22 Set of data arranged in rows and columns (5)
23 Units equal to 1000 watts operating for one hour (4)

CROSSWORD PRIZE

When completed rearrange the highlighted squares to spell out an alkali metal. The first correct answer received will win a £20 Amazon voucher. Email your answer to **jon.excell@markallengroup.com**

November's highlighted solution was scissors. Winner **Bachrun Mason**

WWW.ENGINEERINGSOLUTIONSLIVE.CO.UK

NEW FOR 2020

ENGINEERING SOLUTIONS LIVE

12TH MARCH 2020

BRITISH MOTOR MUSEUM, GAYDON

ONE DAY
ONE VENUE
FOUR GREAT SHOWS

FREE MUSEUM PASS WORTH £14.50 IF YOU PRE-REGISTER

GREAT VENUE!

BRITISH MOTOR MUSEUM

FAST LIVE

LIVE Engineering Materials

PCB DESIGN & MANUFACTURING LIVE

mmm make measurement matter

FIND YOUR FASTENING AND MATERIALS SOLUTIONS IN ONE SIX-HOUR SHOW

Brought to you by the publishers of

newelectronics Eureka! Engineering Materials THE ENGINEER FAST FASTENING & ASSEMBLY SOLUTIONS AND TECHNOLOGY MACHINERY

DCA

Connecting you to the future

MyQuit Band smoking cessation aid

Insight and strategy | Visual brand language | Colour, material and finish | Industrial design | Usability and HF
Interaction design | Mechanical engineering | Prototyping | Production support

www.dca-design.com