T H E E L E C T R O N

N E W S L E T T E R O F T H E I N S T I T U T I O N O F E L E C T R O N I C S

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ADVANCED ENGINEERING 2019

The NEC Birmingham welcomed the return of Advanced Engineering again this year, with around 550 exhibitors and over 200 presentations spread across six dedicated themed zones over two days on 30th. and 31st. October.

To the five established zones of Aero Engineering, Composites Engineering, Automotive Engineering, Connected Manufacturing and Performance Metals Engineering, was added the Medical Device Engineering zone, reflecting the high level of growth currently being experienced in this sector.

Enabling Innovation

This year's exhibition also saw the return of Enabling Innovation, a special area of the show sponsored by PA Consulting Group showcasing ten organisations specially selected by judges from Innovate UK/KTN, The Institute for Manufacturing, and Innovation DB, from a large pool of submissions from industry and research. This provided visitors to the show with an opportunity to view some of the UK's most exciting innovations before they become commercialised.

The ten selected organisations were:

* Fetu Limited (overcoming heat management and compression challenges)

* ES Precision Limited (contributing to a better and more comfortable experience for amputees)

* Holoxia Limited (3D imaging - no headsets, and full-colour motion video images)

* Intra Drive Limited 9new drive train technology for the fast-growing ebike sector)

* Soundcam (a world first in sound imaging technology)

* Optima3D Technology Limited (a groundbreaking development in sD weaving of composites)

* Texture Jet Limited (an innovative new surface processing technology)

* Icomat (a novel carbon fibre process, already with keen interest from aero and auto sectors)

* Fluid Maintenance Solutions (cost-saving technology for metalworking fluid maintenance management)

* University of Nottingham (a new touchscreen machine vision and Artificial Intelligence platform)

Conference Programme

As previously the Advanced Engineering Conference Programme had lots to offer for the electronics professional, and a selection of presentations is as follows:

From the Aero Engineering Forum:

* Digitising C Check Inspections in MRO (Mike Drummond, Commercial Director, Argenta Nova Limited)

* MAGMA Unmanned Aerial Vehicle (Clyde Warsop, Systems Global Engineering Fellow, BAE Systems)

* DRAMA Project 1: Additive Manufacturing for the UK Aerospace Supply Chain (Katy Milne, Chief Engineer, DRAMA, Digital Engineering Manufacturing Technology Centre, and Andrew Mair, CEO, Midlands Aerospace Alliance)

* Additive Manufacturing in Aerospace and Defence: Facts and Forecasts (Dr. Bryony Core, Technology Analyst, IDTechEx)

* Enabling novel Noise Reduction Technologies using Additive Manufacturing Techniques (Professor John Kennedy and Professor Henry Rice, Trinity College Dublin)

* Next Gen 3D-printed Composite Tooling (Jonathan Warbrick, Business Development Manager, Graphite Additive Manufacturing Limited)

* Aerospace in the New - The AI and Data driven Future (Adrian Spragg, Managing Director, Aerospace and Defence Industry Leader, Accenture)

* Harnessing Big Data with Digital Transformation (Kirsty Walker, Channel Marketing Senior Manager, Business Transformation, UK and Ireland, Dassault Systemes, and Ronnie Coupland, Aerospace and Defence Director, Business Transformation, UK and Ireland, Dassault Systemes)

From the Automotive Engineering Forum:

* Autonomous Vehicles (Terry Spall, President Elect, Institution of Mechanical Engineers and Commercial Director, MIRA)

* How will the Lidar Technology and Business Landscape evolve? (Dr. Nilushi Wijeyasinghe, Technology Analyst, IDTechEx)

* Advancing Lidar Technology with Simulation (Zhaoying Li, Applications Engineer, Comsol)

* Delivering Intelligent Solutions (Keynote from Dan Burge, Commercial Director, Lotus Engineering and Technology)

* New Cooling Technology for Electronics in Automobiles (Professor Tom Robinson, Department of Mechanical and Manufacturing Engineering, Trinity College Dublin)

* Optical Measurement for Finite Element Simulation Verification (Rob Wood, Sales Engineer, EIS/GOM UK)

* Re-imagining Engineering with AI (Richard Ahlfeld, Founder, Monolith AI)

* Data driven Services - How Data is driving the Smart Factory (Nishant Raj, Industry 4.0 Lead, Atlas Copco Tools and Industrial Assembly Solutions)

* Intelligent Battery Management to drive the Electric Revolution (Christopher Birkl, CEO, Brillpower)

* How can 3D Optical Metrology support Additive Manufacturing? (Kevin Hawley, Sales Manager, GOM UK Limited)

From the Composites Engineering Forum:

* Robust AI-assisted design of Lightweight Composite Components (Andre Wilmes, CEO, Rafinex Limited)

* Demystifying Composites 4.0 (Marc Funnell, Head of Digital, NCC)

* Technologies Framework for Automated Dry Fibre Placement (Dr. Anthony Evans, Research Fellow, University of Nottingham)

* Active Control of the RTM Process under Uncertainty using Fast Algorithms (Dr. Andreas Endruweit, Associate Professor, University of Nottingham)

* Virtual Un-manufacturing of Fibre-steered Preforms for Complex Geometries (Dr. Jonathan Belnoue, Research Fellow, University of Bristol)

* Smart Tooling - An elegant Solution for manufacturing Unitized, Co-cured Composite Structures (Craig Jennings, President and CEO, Smart Tooling Division, Spintech LLC)

* What is AI and where are the Applications in Tooling for Composites Parts? (Adam Lofts, CTO, Mouldbox)

* Fibre-optic Sensors: The complete Solution for NDT, Structural Health and In-service Monitoring of Composites Structures (Robert Knapp, Director, Epsilon Optics)

From the Connected Manufacturing Forum:

* Optical Metrology - The Future of Measurement (Daniel Steinkellner, Sales Director, Bruker Alicona)

* Industry 4.0 - Hype or Hyper? (Ian Gardner, Industry 4.0 and Oracle Specialist, IBM)

* Generating Value from IIOT Data (Dr. Alexandra Brintrup, Lecturer in Digital Manufacturing, University of Cambridge)

* Digital Transformation in Manufacturing powered by Predictive Analytics (Mohamed Abuali, CEO, IoTco)

* Why Cloud Connectivity, Additive Manufacturing and AI are the Keys to the Factory of the Future (Jeremy Drew, Applications Engineer Manager, EMEA, Markforged)

* Industry 4.0 - unlocking Metrology's Potential (Joe Brennan, Technical Sales Manager, UK and Ireland, LK Metrology)

* Optimisation of Material Design using Deep Learning (Gareth Conduit, CTO, Intelligens)

* Democratising Robotics: The Rise of affordable Automation (Suryansh Chandra, Co-founder, Automata Svetan Ratchev, University of Nottingham)

* Aerospace Assembly in the Digital Age - The FA3D2 (Svetan Ratchev, Cripps Chair of Production Engineering and Director of the Institute for Advanced Manufacturing, University of Nottingham)

From the Medical Device Engineering Forum:

* Brilliant Analytics - Neutron and Synchotron Radiation Applications in Materials Research (Dr. Marc Thiry, Industrial Liaison Officer, Helmholz-Zentrum Geesthacht)

* Approaches to Certification and Standardisation of large Additive Manufactured Parts (Adrian Addison, Team Manager, Arc Processes, Fabrication and Welding Engineering, TWI)

* Disrupting the Medical and Dental Industry with 3D-printing (Bryony Core, Technology Analyst, IDTechEx)

* Additive Manufacturing of wearable/implantable Medical Devices (Dr. Sebastian Pattison, University of Cambridge)

* Hackable Humans - is it literally Life and Death? (Adrian Taylor, CTO, ITC Secure)

* How 3D Simulations can be used to improve Ultrasound Transducer Performance and Fault Detection (Dr. Colin Chung, Project Engineer, Xi Engineering Consultants)

* Accelerating Deep Learning for Medical Image Classification on Qualcomm Mobile CPU and GPU (Syed Hussain, CTO, SplineAI Tech Private Limited)

* Data Trends in Healthcare: Patient Centric Care and IoT (Jason Garforth, Oracle Applications and UNIX Systems Architect, IBM)

Lab Innovations and Maintec

Running alongside Advanced Engineering were two smaller exhibitions, Lab Innovations and Maintec.

Lab Innovations featured 157 exhibitors and 40 presentations, of which the following may be highlighted as being of specific interest to electronics professionals:

* Recovery of Critical Materials: Recycling Automotive Lithium-ion Batteries (Gavin Harper, Birmingham Centre for Strategic Elements and Critical Materials, University of Birmingham)

* Maximising the Information on the Spacial Distribution of Tablet Ingredients using NIR Imaging (Rhys Kelham, IR Product Specialist, Perkin Elmer)

* Using Virtual Reality in the Lab (Pawel Gawkovski, COO, Solution4labs)

* Using Artificial Intelligence to address Scientific Challenges (Professor ji Zhou, Phenomics Group Leader, Earlham Institute)

* Micro GC Fusion - The fastest and easiest Gas Detection in Gas Laboratories (Sarah Wolff, Area Sales Manager Security and Energy Europe, INFICON)

* HPLC Evolution with AI (Dr. Raymond Wong, LC Product Manager, Shimadzu UK)

Key features of the exhibition were notably:

* Laboratory News Village (selected companies that had not previously exhibited)

* Sustainable Laboratory (developed by Andy Evans of Green Light Laboratories and featuring case studies in the use of 'green' equipment from the universities of Oxford, Bristol, Edinburgh and Warwick)

* Insights and Innovation Theatre (created by Laboratory News and featuring presentations on lab management and digitisation in the lab)

* Live Lab (presentations and quick-fire demonstrations on the latest lab innovations)

* Cleanroom Hub

* Royal Society of Chemistry Pavilion

New for 2019 were 'Innovation Tours' hosted twice daily to guide visitors around the most innovative products, and a new matchmaking tool called Lab Connect designed to facilitate networking within the laboratory community.

The 44th. Maintec complemented the other two exhibitions by focusing on the UK's maintenance, reliability, and plant and asset management industry, with a strong emphasis on digitisation within the maintenance function.

There were 78 exhibitors and 26 conference presentations, which were held in two zones, namely Maintec Insights and Reliability Insights. These included:

* Predictive Maintenance Planning: Artificial Intelligence versus Analysis Intelligence (Louis Tuttle, Product Sales Director, PEMAC)

* Merging IT and Operational Technology to maximise the Potential of Digitisation (Keynote by Martin Walder, Chairman of the Engineering and Machinery Alliance and Vice President Industry for Schneider UK)

* The Machine Sentry Automated Diagnostic Assistant - an automated Guidance to Fault Detection (Lee McFarlane, Technical Director, Asset Management, AVT Reliability)

* Emerson's Peak Vue Vibration Analysis Software delivers quick ROI in the Automotive Industry (Will Brown, UK Wireless Solutions BDM, Emerson Automation Solutions)

In this issue of *The Electron* a selection of articles is featured to reflect the diverse areas of electronic engineering covered in these exhibitions.

FORMULA STUDENT AUTONOMOUS CAR COMPETITION

Formula Student, promoted by the Institution of Mechanical Engineers, and showcased at Advanced Engineering, has provided a platform for university students to apply engineering theory in a real world, real project scenario for over 20 years. It requires student teams to design and build a complete race car and compete against other teams from around the world at Silverstone each year.

This year, however, there have been some important new additions to this now well-established event, most notably the introduction of the first autonomous car competition in response to a growing industry need for connected and autonomous vehicle skills. Four universities entered the AI competition and they had access to the IMechE's prototype car, which was part funded by the Centre for Connected and Autonomous Vehicles and was on display at the exhibition. This car, the ADS-DV, lowered the barriers to entry for those who did not have the resources to design and build a running vehicle, but did have software mechatronics and automation engineers ready to create control algorithms to work with their chosen AI hardware in order to complete a set of pre-defined AI missions.

Commenting on the new addition, Simon Shapcott, Head of Research and Development for the Centre for Connected and Autonomous Vehicles, stated:

"Rapid developments in CAV technology, and the new business models which will underpin their use, could fundamentally change the way people and goods move around in the future, offering huge potential benefits in safety, efficiency and productivity. AI is a critical enabler of this future, and Formula Student - AI will help nurture talent on which the UK's industry, from exciting young start-ups to large corporations, will help realise this future for society."

Andrew Deakin, Chairman of Formula Student, added:

"In the future space will be shared between humans and machines. FS-AI will enhance the future of Automotive AI using racing as a testbed."

More information may be obtained from Lucy Killington, Formula StudentProject Manager, on 020 7304 6837. Email: l.killington@imeche.org

DRIVERLESS TRANSPORT FOR ONLINE RETAILING

BITO Storage Systems specialises in the supply of driverless transport systems for online retailers. By reducing travel times for pickers, such a system can save time and money, including with multi-level picking processes and when traversing multi-tier installations.

The company's already established LEO Locative container transporter links workstations in a fulfilment centre with each destination flexibly programmed in as needed and integrated into the transporter's journey.

In *Factory and Handling Solutions* (October 2019, p.28), BITO's Managing Director Edward Hutchinson states:

'Multi-level picking is often a good choice for e-commerce businesses. Compared to single-level or single-item picking, multi-level picking combines multiple orders into a single "pick", with items only later being packed as individual orders. Items are picked off the shelf individually. The use of a downstream sorting process or consolidation station enables picking to be freed to a very large extent from order-specific constraints. Multi-level picking is therefore seeing increasing use in the e-commerce sector.

The container transporter can drive to each picking station where it is loaded up by the picker, and then it carries the containers of orders to collection or packing stations before transferring them to the shipping department.

E-commerce businesses often use multi-tier installations for storage and picking. A good solution in such cases is having an LEO on each floor of the installation.'

There is no Wi-Fi or IT required. Stations where the transporter needs to stop and any tasks that the driverless system needs to perform at each location, are specified using markers, which effectively serve as a 'brain' to the LEO. These contain the information that the system requires in order to perform each task, whether that be stopping, handing over containers, receiving containers or proceeding onwards.

Decentralised Router

Now with proven success, BITO Storage Systems have constructed a prototype LEO that features decentralised routing. The advantages of this are explained by Dennis Ramers, Product Manager, LEO Locative:

"Until now LEO has been able to follow fixed routes in a fixed order. This has made it the simplest 'point-to-point transport system' on the market - and it will continue to hold this title. But now, decentralised routing lets the user send the transport vehicle to different destinations using a simple interface on a tablet. This will open up many new applications for LEO Locative while preserving its key properties: Simplicity, no need for WI-Fi, centralised control and -as a result - low investment costs which pay off very quickly."

ARTIFICIAL INTELLIGENCE REVOLUTIONISES BUS INSPECTION

An Israeli start-up is now using artificial intelligence (AI) to automatically perform visual inspections of the undercarriages of a fleet of 150 buses at an Israeli depot of bus operator Kavim.

Originally designed to detect bombs, the new system, known as UVeye, is installed in a trench near the Modiim depot where it visually scans the buses on their way out and on their return. It detects visual anomalies such as leaks, cracks, bending in components, dents, loose electrical connectors and corrosion.

The article 'Inspector Gadget' by Will Dalrymple in *Transport Engineer* (September 2019, p.31) quotes UVeye (undervehicle eye) Chief Strategy Officer David Oren as follows:

"High-speed digital cameras take multiple images of the undercarriage as the bus drives over. A typical installation of five cameras takes a total of 900 images per second. A site computer processes those images and passes on a data bundle to a cloud-based deep learning engine that runs in the cloud, and analyses the images for anomalies, all within a few seconds.

To do that, UVeye first breaks up the undercarriage into its different elements, and analyses each. It does not compare the image it took with a stored one. Instead, its understanding of

what is normal and what is not relies on training artificial intelligence algorithms that mimic human learning."

Accuracy can be increased by feeding in additional reference information about the vehicles.

UNLEASHING THE POWER OF THE SUPERCAPACITOR

Batteries are the traditional power source for electric vehicles, but supercapacitors (also known as ultracapacitors) with increased capacity and performance are now providing a viable alternative in some applications.

Supercapacitors use electrostatics rather than electrochemical processes, which gives them an advantage in terms of fast charging and millions of discharge cycles which batteries cannot provide. They are limited, however, in that they cannot hold their charge for very long, which means that their use may be optimised in tandem with batteries rather than instead of them when it comes to e-mobility design.

In 'Putting the Super into Supercapacitors' Nick Flaherty in *E-mobility Engineering* (Summer 2019, p.36-41) explains more:

'The performance and properties of supercapacitors are determined to a great extent by the electrode material used. Swiss supplier SECH, for example, uses activated carbon powder. A patented process increases the pore size of the carbon and provides the largest possible accessible surface. Also, the best possible match between the pore size and the ions used in the chosen electrolyte is selected, so that the electrode material has a high capacity and a low internal resistance with electrochemical stability.

The electrode material is processed on an automated production line with a separator in the capacitor winding which is built into a hermetically sealed housing and impregnated with an electrolyte. The capacitors are characterised by laser-welded internal connections to seal the

cell, the use of pure aluminium for housings and electrical contacts, as well as patented housing design. This provides a single-cell voltage of 3.0V with integrated terminals for more compact modules and packs. The internal connections provide a low internal resistance and a path to remove the heat from the supercapacitor.'

Current supercapacitors have an energy density of around 7 Wh/kg, but for wide adoption in e-mobility systems an estimated 60 Wh/kg is required. The postulated solution to this is to use graphene, and the author quotes Sebastian Pohlmann, Head of Cell Development for Estonian supercapacitor manufacturer Skeleton Technologies as follows:

"Right now with the current generation that we produce and on the market you can service niche applications such as active suspension or hybrids. In order to get to the next step the energy density has to double at least. That doubling then services 48V hybrids and the high power peaks that would otherwise damage or degrade the batteries.

If you increase the voltage you also increase the energy density by a factor of squared, so we plan to move from 2.85V to 3.4V. We have prototypes with that voltage, so we know it can be done. Combining that with the electrode material gives us the next generation.

The magic threshold for cell voltage in a 48V system is 3.2V. It means a battery pack can consist of 15 rather than 17 cells, reducing weight and cost. We know from the basic electrochemistry that it should be possible. In theory you can go higher, but 3.4V has proven to be a realistic target.

You can charge a cell to a higher voltage, but the lifetime will decrease quickly - 10 times faster - as the electrolyte is unstable at these voltages, so it decomposes, creating gas and clogging the surface area of the electrode. That leaves less of the energy storage material accessible, so the key point is to find an electrolyte that withstands the voltage without degrading."

The company is currently shipping cell-level prototypes to selected automotive companies and Tier 1 suppliers, and in 2020 plans to do the same with modules and welded packs. Beyond 2020 the company aims to provide production samples of the technology, with a launch planned for 2021.

The cost of the supercapacitors is currently $4,500-5000 per kWh, but the new cells will reduce this to $1,000 per kWh.

Elsewhere in the article the potential of dry electrode supercapacitors is discussed, notably in relation to the Tesla Model 3 electric car, whose range is set to increase from 220 miles to around 375 miles, and five mild-hybrid and plug-in hybrid vehicles from Geely, the owner of Volvo and Lotus. Production of the latter is now imminent.

Another type of supercapacitor that is under development is the ceramic supercapacitor:

'Doubling the permittivity from the eighth generation samples to the ninth generation today cuts the size and cost of a supercapacitor in half without increasing the current leakage. It also holds charge for longer than the previous material, up from 848 seconds to 1,265 seconds, or 20 minutes. This opens up new applications such as supercapacitors in an electric bus to replace batteries. As a bus would stop every 10 to 15 minutes it could be quickly recharged at each stop.

Samples experience less than 15 per cent variation in performance over a temperature range of -30 to +150C, up from -30 to +85C in the previous generation.

Automation company ABB has developed a high-capacity flash-charging electric bus system. A 135-seater bus called TOSA (Trolleybus Optimisation Systeme Alimentation) is charged at selective stops within a 15 second energy boost while passengers enter or leave the bus.

A 400W charging system uses a laser-controlled moving arm that connects to an overhead receptacle for charging at bus shelters, instead of the usual trolley poles to overhead lines. At the end of the bus route a 3-4 minute boost enables a full recharge of the supercapacitors.'

Meanwhile in the UK Wrightbus is working with Skeleton to pioneer the use of supercapacitors in a diesel-hybrid double decker bus, which provides a 36 per cent fuel saving relative to the standard EuroVI diesel.

Hybrid Airship

The application of supercapacitors is not confined to the automotive industry. In the last part of the article Mr. Flaherty explains how the technology is now being adopted in the aerospace sector by French firm Flying Whales. In this case a hybrid airship, the LCA60T, is being developed to carry cargo - up to 60 tonnes, for example, of timber - in a 75-metre long hold, or underslung. This will have a top speed of 100 kph and a daily range of some several thousand kilometres:

'Engineers from Skeleton are helping to develop the 1.5 MW propulsion system for the helium-filled, rigid structure airship, using supercapacitors to provide an extra 2 MW for hovering, lifting and stabilisation.'

NEW LIGHTWEIGHT AIRFRAME FOR AUTONOMOUS DRONES

A lightweight airframe design for an autonomous drone has been developed by Sheffield Robotics with help from engineers at the University of Sheffield Advanced Manufacturing Research Centre.

The project was part of the EPSRC Brains on Board programme to develop a series of autonomous drones capable of processing sensor data in real-time so as to control their own flight.

The AMRC's Design and Prototyping Group used additive manufacturing to meet strict weight limits imposed on the airframe and the requirement to test multiple iterations of the design.

The article 'Helping Drones lose Weight' in *AMRC Journal*, Issue 10, p.22-23 explains more:

'The flight control algorithm of the drone is based on that of a honey bee. In previous versions of the drone, Sheffield Robotics have successfully achieved a real-time processing of sensor data by performing all necessary computing tasks on a remote base station and sending the data wirelessly.

The goal of the Brains on Board project is to perform all required computing tasks on board, eliminating the need for a remote base station. To perform data processing on board, additional computing modules need to be housed within the drone, which add to its flying weight. To maintain the required thrust to weight ratio of the drone, while still housing these additional computing modules, significant weight savings were required to the airframe.

To maintain the required thrust-to-weight ratio for the selected motors, a strict upper weight limit of 600g was imposed. In addition to this, there was little flexibility in the selection of the components. This meant that the maximum airframe weight was restricted to 98g. By comparison, commercially available airframes for similar sized quadcopters are normally in the 200-400g range. In addition to the weight limit, there was a requirement for the frame to protect the electronic components in the event of a hard landing.'

Idea generation led to two options:

(i) Strut-and-node where a framework of lightweight tubes were connected to nodes.

(ii) Laser cut carbon fibre plates connected by a series of rigid fastners.

Prototype designs were constructed for the first option, but the resulting complex node geometry requirement led to the conclusion that this option, contrary to initial speculation,

was not going to lead to the desired weight requirement. So the second option was then explored:

'A basic prototype of the airframe designed to make use of laser cut carbon fibre plates was manufactured. To reduce development time, AMRG DPG used the Markforged fused deposition modelling (FDM) printer to manufacture the bespoke carbon fibre connectors.

The Markforged printer is capable of printing components in a proprietary ABS and chopped carbon fibre material called Onyx. The strength of Onyx components can be enhanced by inlaying strands of carbon fibre into them as they are built. This results in components with very similar material properties to carbon fibre.'

Flight tests displayed thrust and hover performance that was 'satisfactory', but 'significant' flex was observed in the frame as it changed direction. This was a matter of concern because it was known that significant movement in the frame could cause problems with the control algorithms. The torsional rigidity of the frame was thus deemed to be 'insufficient', necessitating a redesign. The redesigned frame had more depth and test flights using this frame revealed that it was now 'sufficiently stiff'.

In parallel with the frame design AMRC DPG also designed, prototyped and tested various structures capable of cushioning the frame during impact. Initially a landing gear manufactured in nylon using an FDM process was produced, but weight restrictions precluded this from inclusion in the final frame. Smaller landing feet, manufactured in Formlabs' tough resin, were therefore used, providing 'a good balance of impact protection and lightweighting'.

More information is available from amrc.co.uk/capabilities/additive-manufacturing

ROLLS-ROYCE AND QATAR AIRWAYS USE VIRTUAL REALITY TO TRAIN ENGINEERS

Rolls-Royce and Qatar Airways are now using virtual reality to train engineers in a first for the two companies.

Rolls-Royce is incorporating virtual reality into its engineering training programmes under its Intelligent Engine vision and Qatar Airways engineers are the first in the industry to receive the training using Rolls-Royce's pioneering Trent XWB engine, which powers the Airbus A350. As Qatar Airways were the first customer to take delivery of the Trent XWB, Rolls-Royce's largest engine, the airline was ideally placed as a launch partner for the technology.

The scale of the Trent XWB is such that it has to be separated before engineers can transport it for maintenance and repair. Using HTC Vive equipment, engineers are immersed in the process using sight, sound and touch to separate the two parts of the engine in a virtual setting, rather than having to physically transport an engine to Doha to be used for the training, or provide an engine in service with the risk of damage to equipment and loss of valuable flying time.

In the article with the above title in The *Essential Guide to Maintenance Management 2019-20* (an *Industrial Plant and Equipment* special supplement published by Maintec), p.14, Customer and Product Training Manager for Rolls-Royce, Steve Buckland, who developed the VR training programme, is quoted as follows:

"Virtual Reality has a valuable application here. It's going to save time and money, and frees up engines that could otherwise be on aircraft keeping passengers moving.

We're looking at creating holograms of an engine that we can use to teach in a classroom, or Augmented Reality that can be overlaid over a real engine to show technical information. Nothing will beat learning with an engine and this will never be replaced, but new technology is allowing us to be innovative with the ways we teach engineers."

LASERS PRODUCE SHARK SKINS ON AIRCRAFT

Leading aircraft paint supplier Mankewicz and laser specialist 4JET have partnered to introduce a new laser process for the creation of fuel saving riblets automatically lasered onto painted aircraft surfaces.

The technology, known as Laser Enhanced Air Flow, or LEAF, uses the principle of laser interference patterning to quickly create fine lateral grooves in the uppermost layer of aircraft paint.

The article with the above title in *Aerospace Manufacturing* (October 2019, p.46) describes the process:

'Different from the known laser technologies, 4JET has now found a way to speed up the process by a factor of about 500. The laser beam is split up and recombined on the surface in such a way that the electric field oscillations of the light waves superimpose in a controlled manner. This enables the creation of 15 km of riblets - equal to about 1 square metre of riblet surface - within less than one minute.

The riblets produced by lasers have been proven to reduce drag by up to 10 per cent which results in fuel savings for commercial long haul airlines by more than 1 per cent - equalling tremendous potential savings on total global kerosene spending of US $150 million annually.

Adding even more benefits, LEAF is working dry without any consumables. It allows adjustment of riblet geometries depending on their location on the aircraft. The paint dust and vapour created during the process is evacuated and the process does not require post-processing. The technology is able to process curved or riveted surfaces and can be integrated with existing robotics used for paint removal or printing operations in aircraft maintenance.'

NEW SYSTEM FOR MONITORING SPINDLE BEARINGS ON MACHINE TOOLS

Automotive and bearing specialist Schaeffler has developed a new electronic system for monitoring the spindle bearings on machine tools which are subjected to high loads during operation.

The main spindle on a machine tool is crucial to its performance capability and largely defines the achievable cutting capacity, surface quality and precision. The spindle bearing support is also one of the most heavily loaded components because it must transmit machining forces precisely at very high speeds for long periods of time. It follows that the majority of machine tool downtime can be traced back to defective spindles, particularly as a result of collisions and continuous undetected overloads.

The article 'Sensing Wear on the Spindle' in *Production Engineering Solutions* (October 2019, p.28-29) describes the new SpindleSense system, which now gives operators the ability to monitor borderline loads on spindle bearings:

'The sensor ring transmits an electrical warning signal to the machine's control system if the deflections measured on the rolling elements exceed a specific threshold, which is set individually for every spindle and machine type. The threshold is based on an assessment of operation-related bearing parameters such as pressure, spin/roll ratio, and cage pocket clearance.

All the software and the required algorithms are integrated into the 16mm wide sensor ring. No further components are required for the system, which is locally functional and transmits an individual warning signal to the machine's control system.

The operator can adjust the machining program right after the first manufactured part and reduce the spindle load by using a new tool or modified cutting values, or by employing a more suitable tool type. The operator thus achieves lower and less numerous peak loads and so benefits from a longer spindle operating life with fewer machine tool downtimes.

For the first time ever the machine operator will know the degree to which the spindle capacity in each machining process is being utilised as a percentage with a high level of accuracy and therefore will be able to adjust the machining process even more precisely in terms of capacity utilisation and operating life for each machine. This means that harmful overloads are prevented despite maximum spindle loads.

Compared to mechanical, i.e. passive overload systems, Schaeffler SpindleSense does not just protect the spindle in the event of a collision; it's also a revolutionary system for safely maximising the utilisation of the spindle capacity.'

WORLD'S FIRST SATELLITE SERIAL PRODUCTION LINES

OneWeb Satellites is using Lanner's digital twinning to design two factories, one in Toulouse and another in Florida, to create the world's first satellite serial production lines, with the objective of producing a satellite constellation that will provide high-speed internet access worldwide.

Until now satellites have been designed and manufactured manually on a small scale with manufacturers constructing a handful of satellites per year, but with these new facilities this is set to change with up to several hundred being produced every year.

Lanner began working with OneWeb Satellites in 2017 with Lanner's Witness Horizon model being applied to provide predictive simulation to create a 'virtual factory' to produce a comprehensive picture showing precisely what the facility will look like, how it will operate under normal conditions, and how it will respond to changes as they evolve. This assists planners to pinpoint exactly what processes and resources will be required to ensure that demand is met.

[Reference: 'Predictive Digital Twins design Satellite Production Line', *Efficient Maintenance* Supplement, September/October 2019, p.3].

3D PRINTED GUITAR IS UNBREAKABLE

3D-printing specialist Sandvik has used additive manufacturing to produce a stainless steel guitar that the company claims is 'unbreakable'.

Swedish rock legend Yngwie Malmsteen was invited to play the instrument and afterwards attempt to smash it, but he couldn't.

More information is available on 0121 504 5111.

QUEEN PERFORM IN ATOMIC RECORDING STUDIO

US physicists have used a system based on Rydberg physics to reproduce the iconic sound of the rock band Queen, as well as simultaneously recording sound from two guitars, using atoms in a vapour.

The experiment, carried out by Chris Holloway and colleagues at the National Institute for Standards and Technology (NIST) in Boulder, Colorado, is expected to have implications especially for improvements in quantum communications, notably in deep space where very weak signals have to be used.

In the article with the above title in *Physics World*, Vol. 32, No.8, August 2019, p.5, Sam Jarman explains:

'Rydberg physics is a burgeoning field that focuses on the properties of Rydberg atoms - atoms with one or more electrons excited to very high energy levels. Since these excited electrons are relatively far away from their host nuclei, Rydberg atoms have huge dipole moments. The atoms therefore interact strongly with radio and microwave signals used in telecommunications.

The NIST researchers used a "Rydberg radio" - which consists of a vapour of Rydberg atoms in a small chamber - to receive, store and then transmit radio and microwave signals. These devices have been demonstrated in several recent studies and are examples of practical quantum-scale receivers.

The team, however, pushed the capabilities of Rydberg radio further than ever before via their atomic recording studio, which stored Holloway's own improvised guitar solos inside a Rydberg vapour cell in real-time. They were able to do multitrack recording of two guitars using a vapour that contained two different types of Rydberg atom. One guitar track was recorded by caesium and the other by rubidium.

Finally, they used the same set up to record Queen's track "Under Pressure". While one atom species handled the instrumental part of the track, the other recorded the vocals and managed to cope with Freddie Mercury's extensive vocal range. Holloway's team acknowledges that limitations in sound quality mean that Rydberg radio will not be replacing digital recording devices any time soon, but still hopes to produce an "atomic record" in their studio, potentially inspiring a new generation of quantum researchers.'

THE TERAFLOP SWARM: SWARM BOTS THAT LEARN AND EVOLVE

Researchers at the University of Bristol and the University of the West of England have used artificial evolution to enable swarm bots to automatically learn swarm behaviours that are

understandable to humans. This ability to learn and evolve opens up new possibilities for environmental monitoring, disaster recovery, infrastructure maintenance logistics and agriculture.

Until now artificial evolution has typically been run on a computer, which is external to the swarm, with the best strategy then copied to the robots. This approach, however, is limiting because it requires external infrastructure and a laboratory setting.

By using a custom-made swarm of robots with high processing power, embedded within the swarm, the Bristol team was able to ascertain the rules that give rise to desired swarm behaviours. From this it may be possible to develop robotic swarms that can continuously and independently adapt in the wild. By making the evolved controllers understandable to humans, the controllers can also be queried, explained and improved.

The article 'A Step closer to Swarm Bots that can independently learn and evolve' (adapted from *Advanced Intelligence Systems*) in *Operations Engineer*, Issue 12, October 2019, p.8, explains how the team, co-led by Dr. Sabine Hauert, Senior Lecturer in Robotics in the Department of Engineering Mathematics, University of Bristol, took advantage of recent advances in high-performance mobile computing to build a swarm of robots inspired by those in nature:

'The "Teraflop Swarm" has the ability to run the computationally intensive automatic design process entirely within the swarm, freeing it from the constraint of offline resources. The swarm reaches a high level of performance within just 15 minutes, much faster than previous embodied evolution methods, and with no reliance on external infrastructure.'

Dr. Hauert is quoted as follows:

"This is the first step towards robot swarms that automatically discover suitable swarm strategies in the wild. The next step will be to get these robot swarms out of the lab and demonstrate our proposed approach in real-world applications."

Professor Alan Winfield of the Bristol Robotics Laboratory, and Science Communication Unit of the University of the West of England adds:

"In many modern AI systems, especially those that employ deep learning, it is almost impossible to understand why the system made a particular decision. This lack of transparency can be a real problem if the system makes a bad decision and causes harm. An important advantage of the system described in this paper is that it is transparent: its decision-making process is understandable by humans."

WORLD'S FIRST SELF-CALIBRATING TEMPERATURE PROBE

The TrustSens TM371 temperature sensor from Endress+Hauser features unique technology that, for the first time, provides fully automated inline self-calibration without process interruption.

The sensor's self-calibration function saves time and costs by converting a normally manual exercise into a fully automated procedure. This reduces the need for calibration equipment, frees up on-site engineers for other activities and reduces the risk of product wastage caused by incorrect temperature measurement. Any drift of the inbuilt temperature sensor would be quickly detected rather than waiting to be discovered during the next manual calibration cycle.

Designed primarily for use in the food and beverage industry, TrustSens is fully compliant with FDA and GMP guidelines. An audit-compliant calibration certificate is digitally produced and stored within the temperature probe and can be downloaded at any time.

[Reference: *Food and Drink International*, October 2019, p.31].

RCD DIRECT CURRENT WARNING

With the recent 18th. Edition of the IET Wiring Regulations including updated guidance on the use of various types of residual current device, Bureau Veritas has expressed concern about AC type RCDs being adversely affected by direct currents from electronic devices and renewable energy sources.

In 2001 the 17th. Edition (Amendment1) recommended AC type RCDs for use in sockets that were likely to supply outdoor equipment, but with more homes and commercial sites now using electronic equipment and installing renewables such as solar PV, there is now a concern that some of these RCDs may be unfit for purpose. This has led to a recommendation that A or B type RCDs, which are specifically designed to offer protection against alternating and pulsating direct currents, should be used in preference, in line with the recent rewrite of 531.3 in BS 7631.

The article 'Bureau Veritas issues Direct Warning on RCDs' in *Manufacturing Engineering Process Control Automation*, November 2019, p.10, quotes Bureau Veritas' Technical Manager, Michael Kenyon, as follows:

"Modern electrical installations are now more than ever incorporating technologies and products that manipulate the current waveforms. These devices, such as solar PV and electrical vehicle chargers could be leaking direct current back into the electrical system and saturating the iron core of the AC type RCDs which are not designed to handle it.

This is a particular problem when dealing with poor quality electronic equipment or substandard installations as DC leakage current can be created by faulty equipment such as solar PV, EV chargers, variable speed drives and even faulty mobile phone chargers or USB sockets. Inevitably, we're seeing RCDs being increasingly affected by DC - putting many people at risk.

The rewrite of 531.3 has undoubtedly led to an increased awareness of the different types of RCDs on the market, but in terms of promoting best practices, at the moment it just doesn't

go far enough in recommending the use of A type RCDs. In fact, regulation 531.3.3 still states that for general purposes, Type AC RCDs should be used coupled with the disincentive that Type AC RCDs are still much less readily available.

From our experience, we'd recommend A Type RCDs for general use, although going forward this will need to be supported by regulation, the industry and even manufacturers as the majority of devices found online were still AC Type and the A type devices remain significantly more expensive."

SIEMENS LAUNCHES DIGITAL ACADEMY

Siemens has this year launched a new undergraduate sponsorship programme to discover and nurture the next generation of engineering talent.

The Digital Academy pays selected students £3,000 per year from the second year of university plus up to twelve weeks of summer placement throughout the duration of their studies within a Siemens business. At the end of their degree the students are offered the opportunity to join the Siemens Graduate Scheme.

The pioneering programme is a partnership between Siemens, the University of Sheffield, Newcastle University and a further 15 principal UK universities. It aims to offer undergraduates a practical, collaborative space to explore Industry 4.0 technologies and apply what they learn at university to real-life projects.

Six students from electrical and electronic engineering and computer science departments were selected to pilot the programme from the inaugural Sir William Siemens Challenge, a two-day 'hackathon' style event held at the University of Sheffield, which involved 84 promising engineering students from the partner universities.

The challenge, named Mindsphere Live, placed the students into twelve hybrid multi-disciplinary teams and asked them to invent a unique device powered by data.

More information is available from www.siemens.co.uk/digitalacademy

CAMBRIDGE AND PAPWORTH ACHIEVE FIRST IN ELECTRONIC PATIENT RECORD INTERFACING

Royal Papworth NHS Foundation Trust and Cambridge University Hospitals NHS Foundation Trust have achieved a first-of-type in the UK by interfacing their electronic patient record systems, enabling blood test orders and results to be shared between the two organisations.

Royal Papworth Hospital has just moved into a state-of-the-art building on the Cambridge Biomedical Campus, alongside Cambridge University Hospitals (Addenbrooke's and The Rosie Hospital). The two trusts share a pathology service, so ahead of the move a complex piece of IT integration work was undertaken to enable timely sharing of blood tests for patients at Royal Papworth. Key to this was the first-of-kind integration development between the DXC Lorenzo EPR system used by Royal Papworth and the Epic EPR used by Cambridge University Hospitals NHS Foundation Trust.

The article 'Blood Test Project puts Cambridge and Papworth ahead in IT Interoperability' in *Pathology in Practice*, Vol. 20, Issue 4, August 2019, p. 12-13, explains how, from the Papworth side, this was achieved using the hospital's Viaduct integration engine (another DXC product):

'Viaduct manages all of the HL7 messaging between systems at Royal Papworth and communicates directly with the Ensemble integration engine at Cambridge University Hospitals. Where appropriate, Viaduct sends text requests to Addenbrooke's for its laboratories to process. On return, the test results are directed to the appropriate system - Lorenzo, if patients are on a hospital ward, or the system in use on the critical care unit - so that they are easily available to the attending clinicians'

Chris Johnson, Chief Medical Information Officer at Royal Papworth, is quoted as follows:

"Prior to the integration, we would order a test using our order communication system. If the test was going to be at Addenbrooke's Hospital, we would print out the request, marry it up with the blood bottle, and send it over to the laboratories at Addenbrook's, where it would be transcribed into the Epic EPR.

When the test was completed, the result would be automatically emailed back as a pdf due to the lack of integration between the trusts' systems. Administrative staff at Royal Papworth would have to open up the pdf, rename it, add some patient identifiers, and save it into a file-drop so it could be sucked up into our document management system. Or, if it was numerical data, our qualified laboratory staff would have to sit down at a computer and transcribe the details from these pdfs into our laboratory system, so it could display the results to clinicians. It was an extremely laborious process, prone to error, prone to delay. With the EPR integration, all of that work has now gone away.

Thanks to the collaboration we are now receiving results digitally within 48 hours, which means that clinical decision-making can happen far more quickly."

Patient safety has also improved because there are fewer points at which complex results must be copied from one form or system to another and the project is noted to have 'national significance' as it proves that hospitals do not have to be using the same EPR system to exchange information with each other.

NHS LAUNCHES ACCREDITED SUPPLIERS FOR ELECTRONIC PATIENT RECORDS

NHSX and NHS England have published a list of accredited suppliers for electronic patient record solutions in an attempt to give purchasers in the NHS more confidence in their route to digitisation.

NHSX and NHS England have developed a new section on the Health Systems Support Framework to help organisations and integrated care systems obtain the best value for money when purchasing new digital services, software and infrastructure.

Bidders were evaluated by experts from NHS England and Improvement, NHSX, NHS Digital, Department for Health and Social Care, local care provider organisations, regional teams and national bodies. Stakeholders included Chief Inspection Officers, Chief Clinical Information Officers, Chief Nurse Information Officers, Clinical Safety Officers and front-line clinical staff.

Bidders were evaluated against a variety of functional requirements within existing deployed solutions. Suppliers were permitted to offer this functionality within a sole solution or across multiple integrated solutions within a supply chain partnership.

The suppliers also had to demonstrate how they would deliver enterprise-wide solutions, how they could provide thinner deployments that provide a basis for modular solutions (with or without SMEs and other partners), how the vision set out in 'The Future of Healthcare: our Vision for Digital, Data and Technology in Health and Care', and how they would interoperate with other systems to ensure that data is available to clinicians at the point of need and to support the creation of integrated local health and care records.

Eight suppliers were successful, namely Allscripts, Cerner, DXC, IMS Maxims, Nervecentre, Meditech, TPP and System C. These are now on the Lot 1 List.

[Reference: *Clinical Services Journal*, Vol. 18, Issue 8, September 2019, p.13].

BIODEGRADABLE BATTERIES MADE FROM PROTEINS

The first battery to be made from custom-built proteins has been created by scientists in the United States.

In place of metal components, the battery's electrodes contain polypeptides that have been modified to shuttle electrons with radox-active groups.

The 1.5V prototype, with electrons made from coils of polymerised glutamic acid units, was engineered by Jodie Lutkenhaus, Tan Nguyen and Karen Wooley of Texas A and M University.

The article 'Biodegradable Batteries could be made from Modified Proteins' by Katrina Kramer in *Chemistry World*, Vol. 16, Issue 10, October 2019, p.12, states:

'To give the peptide its electron-shuttling ability, the team decorated the polymer chains with one or two redox-active compounds: the stable radical Tempo on the cathode, and a bipyradine viologen on the anode.

Since the electrodes only contain peptides mixed with carbon particles, they could degrade by natural means - though the toxic viologen might pose a problem.'

An alternative, proposed by Ms. Lutkenhaus, would be to trigger the battery peptides externally to degrade into their original starting materials for reconstruction into fresh battery peptides.

The prototype delivers up to 1.5V and 40-50 mAh/g for 50 cycles, after which it loses capacity. It is suspected that this is a result of the protein dissolving in the electrolyte.

Since polypeptide sequences can be tailored to create different 3D structures, the team is now working to ascertain which structural arrangement provides the best overall electron transfer performance.

It is envisaged that these new batteries will be used initially for single use applications such as biometrics and health data monitoring.

It is hoped that, in time, these new batteries will offer an improvement on the present environmental position with lithium-ion batteries, only 5 per cent of which are currently recycled.

AI BIOMARKER TO PREDICT HEART ATTACKS

Laboratory News (October 2019, p.9) describes how a new AI-powered biomarker has been created that can 'predict heart attacks at least five years before they are due to happen'.

It has been developed by a team at Oxford University that has created a fat radiomic profile, or FRP, which uses machine learning to detect biological 'red flags' in the perivascular s0pace lining blood vessels to the heart, such as inflammation, scarring and other changes.

The researchers say that FRP can predict heart attacks more effectively than tools that are currently used in clinical practice, and may also lead to more personalised health care.

At present there are no methods that can be used routinely to detect the underlying red flags for a future heart attack. The article 'AI Biomarker predicts Heart Attacks', adapted from the *European Heart Journal*, states:

'To build the biomarker, the research team used fat biopsies from 167 people undergoing cardiac surgery and analysed gene expression associated with inflammation, scarring and new blood vessel formation. They then matched these to angiogram scan images to determine which features best indicate changes to fat surrounding heart vessels.

They then compared the scans of 101 people who went on to have a heart attack or cardiovascular death within five years of having a CCTA with matched controls who did not, to understand the changes in the perivascular space. As with any machine learning model, the more heart scans that are added, the more accurate predictions will become.'

Charalambos Antoniades, Professor of Cardiovascular Medicine and BHF Senior Clinical Fellow at the University of Oxford, is quoted as follows:

"This has huge potential to detect the early signs of disease, and to be able to take all preventative steps before a heart attack strikes, ultimately saving lives. We genuinely believe this technology could be saving lives within the next year."

ARKWRIGHT ENGINEERING SCHOLARSHIPS

The Institution of Electronics was proud to be a sponsor again of the annual Arkwright Engineering Scholarships.

Supported by the Institution of Engineering and Technology, The Arkwright Engineering Scholarships Programme is one of the most prestigious scholarship schemes of its type in the UK with over 5,000 scholarships awarded to date.

This year four Awards Ceremonies took place over three days, three in London and one in Edinburgh, with just over 400 scholarships being awarded.

The Institution of Electronics' sponsored student was Fred Dally of the King Ecgbert Sixth Form in Sheffield, who is currently studying Maths, Further Maths, Physics and Computer Science at Advanced Level. He received his certificate on 31st. October at the Awards Ceremony at the IET London, where this year's theme was 'A Celebration of Women in Engineering'.

In keeping with this the Guest Speaker for Day One was Wing Commander Gemma Lonsdale of the Royal Air Force, who pointed out that whilst the RAF employs some 18,000 engineers out of a total of 35,000 employees, just 6 per cent of these engineers were women. She said, notably that "Women in engineering offer a different way of thinking" and "if everyone is thinking the same, nobody is thinking".

She was joined by Dr. Alan Begg, Chairman of the Smallpeice Trust, which manages the programme, who highlighted the key role that engineering has in driving economic growth and productivity, being responsible for generating over 20 per cent of the UK's turnover. In his introduction he stated:

"It is well documented that only 12 per cent of all engineers in the UK are women. Research suggests, a fifth of women see the disparity in those thinking about pursuing engineering and those who follow through could be down to a lack of visible role models. This becomes most evident when considering the 28 per cent of women who don't think they are clever enough to consider pursuing a career in engineering."

Currently 30 per cent of Arkwright Engineering Scholars are women, but there are plans to triple the number of female Scholars over the next five years.

David Lakin, Head of Education, 5-19, for the IET, added:

"It's engineers that change the world and are responsible for engineering a better world."