TIME FOR ‘T’?

THE RISE OF THE MULTI-DISCIPLINARY, ‘T-SHAPED’ ENGINEER

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CAPITAL IDEA

Businesses may be missing out on tax relief and efficiency gains by not taking advantage of Enhanced Capital Allowances.

COFFEE TIME

CHALLENGE FOR THE BIRDS

This month’s challenge is to help arable farmers, who are constantly looking for ways to scare birds away from their valuable crops.
Fun fact: Filling water balloons involves complex FSI.

Preparing water balloons for a friendly competition outside is a classic summertime activity. Have you ever thought about the physics at play? Filling the balloon can be a delicate task — too much water and you might get splashed before the games even begin. To study the interaction of fluid pressure and the nonlinear structural material of a water balloon, you can turn to FSI simulation.

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comsol.blog/water-balloon
EDITOR’S COMMENT

GIVING BACK

ON OCTOBER 4, the annual British Engineering Excellence Awards luncheon took place in London. As ever, it provided a heartening insight into the world class innovation and invention that exists in the UK engineering sector, with some truly outstanding entries from whom the very best were chosen as winners.

Who won what can be seen elsewhere, but what the BEEAs continue to show is the value of an event that recognises the achievements of British engineering.

When these awards were launched in 2009, things were very tough. The fallout from the global financial crisis was still being felt, the country was in and out of recession and, despite much talk of the need to rebalance the economy, the mood music around UK manufacturing and engineering was often downbeat, with a distinct shortage of good news stories and a marked unwillingness to acknowledge them where they did exist.

With that in mind, we set out to find those good news stories and to make sure they didn’t go unnoticed. This we sought to achieve by highlighting the extraordinary, often unsung achievements of British engineering. By giving the most innovative, dynamic and impressive engineers in the country a stage for the public recognition of their achievements, the BEEAs have helped to give this crucial sector of our economy the status it merits.

That said, the fact is that, however accomplished an individual may be, they can only achieve that level of accomplishment by virtue of being part of a healthy industry. Without ensuring that that industry stays healthy and well-supplied with the brightest and best young people, we may be preventing the next generation of BEEAs winners from developing. This is why those who give back to the profession so often feature as winners.

I would like to take this opportunity to congratulate all this year’s winners.

Paul Fanning, Editor

FAULHABER BXT

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EUREKA!  NEWS

EDS delivers design innovations

THE ENGINEERING DESIGN Show 2018, and it’s co-located Embedded and Electronics Design Shows, closed on Thursday 18 October with overwhelmingly positive feedback from exhibitors and visitors. Running from 17-18 October at the Ricoh Arena, Coventry, the show highlighted the cream of British design innovation.

This exciting two-day event played host to 21 thought-provoking conference sessions with world-class engineering design experts, including, Mercedes AMG Petronas F1, Plug-In Adventures, Smiths Detection, The Manufacturing Technology Centre, Stratasys and ANSYS. In addition, the exhibition housed three workshop theatres open to visitors wanting to learn new skills or take away practical design tips and expert advice.

Mike Bray, vice president DesignSpark-RS Components, said: “This is the premiere show in the UK. The expansion of the different zones and the number of different speakers and conferences makes it a hugely credible show to come to.”

Richard Mount, director of sales, Swindon Silicon Systems, said: “From the show a couple of years ago we actually found one of our most recent customers. It’s a perfect venue and location, and the footfall and who we’ve seen is perfect for what we want”

Mike West, business development, Lee Springs, said: “It attracts the right sort of buyer who we try to connect up with. This is the seventh time we’ve been here, and I think we’ll probably be back next year.”

The Engineering Design Show will return to the Ericsson Exhibition Halls, Ricoh Arena, Coventry from 16-17 October 2019.

£4.1M MANCHESTER FUEL CELL INNOVATION CENTRE OPENED

THE MANCHESTER FUEL Cell Innovation Centre (MFCIC) – a £4.1m facility dedicated to developing sources of emission free energy and making it available to as many people as possible - has been opened at Manchester Metropolitan University.

The Centre will be at the forefront of hydrogen and fuel cell technology, which creates sustainable electrical energy through a chemical reaction between hydrogen and oxygen – with water as the only by-product. The technology could power homes, offices, factories, cars and public transport – making them more efficient and not dependent on the main power grid.

Fuel cells have higher efficiency than diesel or gas engines, operate silently and produce just heat and water as waste products. They can be used to store energy efficiently, which other forms of renewable energy currently struggle to do.

Professor Malcolm Press, vice-chancellor of Manchester Met, said: “MFCIC will be a regional hub for research innovation and economic growth in the fuel cell technology sector. This is crucial both environmentally and economically for the region, as the UK focuses on increasing its use of renewable energy and lowering emissions.”

Over the coming months, MFCIC will run workshops to show SMEs how they can improve efficiency and open new market opportunities by collaborating with researchers and incorporating hydrogen and fuel cell technology.
Full-colour, multi-material 3D printing

**SHAPEWAYS AND STRATASYS** have partnered to make full-colour, multi-material 3D printing more accessible to designers and engineers so they can build highly realistic prototypes with streamlined design-to-prototype workflows, decreasing both time-to-market and -revenue.

Greg Kress, CEO of Shapeways, said: “The vivid colours of the Stratasys J750 3D Printer will enable the Shapeways community of designers, businesses, students, and artists to realise their brightest ideas and boldest ambitions in true physical form with full-colour, texture mapping and colour gradients.”

The J750 offers more than 500,000 colour combinations, accurate colour-matching, transparent to opaque colour gradients, and clear material with texture for fine details. The PolyJet-driven machine creates parts that look, feel, and operate like finished products and eliminates the need for painting, assembly or heavy post-processing.

Shapeways will help design printable objects that fully utilise the printer’s capability, running the printers at scale, and delivering finished products that are ready to use or sell.

Beta customers will be able to access the service before the end of the year, with a full launch expected in 2019.

**NETWORKED MOTORS**

MOTOR AND DRIVE technology manufacturer, WEG, has unveiled the WEG Motor Scan, which delivers remote monitoring of motors to maximise uptime and enable predictive/preventative maintenance.

WEG Motor Scan captures operating data in real time and can monitor any number of motors via an app. On the basis of selected operating data, operators and maintenance staff can schedule and execute predictive maintenance as indicated by the condition of the motor. The gathered data can be transmitted securely to the cloud, from where it can be retrieved via a mobile app, web portal or the WEG IoT platform.

This data enables detailed analysis of the electric motor and enables longer motor service life and enhanced system availability. This condition monitoring solution can be mounted as a retrofit option. Its IP66 protection suits WEG motor scan for a range of industrial applications.

The BEEAs knees

COMMENDED FOR ITS work in encouraging increased interest in engineering and promoting the uptake in STEM subjects, AESSEAL, specialist in the design and manufacture of mechanical seals and support systems, took home this year’s title of Grand Prix winner at the BEEAs ceremony.

Held at etc. venues in County Hall, London, on October 4, 2018, the day saw a whole host of extraordinary talent win out, including Design Engineer of the Year, Orla Murphy, and Young Design Engineer of the Year, Brent Brakeboer, both of whom have been deeply involved in outreach activities – an important quality the BEEAs judges look for in its winners.

Luke Webster, publishing director of awards organiser MA Business, said: “Once again, the BEEAs has attracted a host of impressive entries from brilliant British innovators. Through every category, the judges were deeply impressed by the quality of engineering put forward and the talent behind it. I congratulate all those entrants that were shortlisted and, of course, the winners.”

Further coverage of the BEEAs 2018 can be found on page 36.

**AND THE WINNERS ARE…**

- **Consultancy of the Year**
  - Stirling Dynamics
  - Sponsored by: Rutland Plastics

- **Small Company of the Year**
  - Transmission Dynamics
  - Sponsored by: MA Business

- **Start up of the Year**
  - Circuitworx
  - Sponsored by: Cambridge Consultants

- **Materials Application**
  - Nylacast Chock Liner
  - Sponsored by: Goodfellow

- **Electronic Product of the Year**
  - Xilinx
  - Sponsored by: TÜV SÜD

- **Mechanical Product of the Year**
  - Aeristech
  - Sponsored by: MiniTec

- **Design Team of the Year**
  - Imagination Technologies
  - Sponsored by: LG Motion

- **Engineering ambassador of the Year**
  - AESSEAL
  - Sponsored by: John Guest

- **Young Design Engineer of the Year**
  - Brent Brakeboer, Surrey Satellite Technology
  - Sponsored by: RS Components

- **Design Engineer of the Year**
  - Orla Murphy, Jaguar Land Rover
  - Sponsored by: maxon motor
Jigs & Fixtures on the Factory Floor

BOOM Supersonic

BOOM’s mission is concise: to make the world dramatically more accessible by creating an aircraft that’s twice as fast as today’s commercial air fleet. But in an industry where innovation fuels success, the importance of tooling to support rapidly evolving designs can’t be underestimated. “This is where the 3D printer shines,” says Ryan Bocook, manufacturing engineer.

With additive manufacturing, “we can design and build a custom tool in a matter of hours.”

Cost savings are significant with additively manufactured jigs and fixtures. “I recently had a small part for an assembly fixture quoted from two machine shops. Both came in over $1K higher per part than what I could 3D print them for,” said Bocook. “Not to mention lead time and shipping.”

3D Printed Tools for Better Ergonomics, Speed and Design Complexity

Advice from BOOM’s Ryan Bocook:

1. Many shop floors limit the use of their 3D printers to a select few. “This is counterproductive. Let your team explore the possibilities. Give access to the full shop. Give them a material budget and time on the machine. I bet they will be printing things that will revolutionize your approach.”

2. Choose the right 3D printer. All the benefits of 3D printing, including speed, cost and iterations are lost if the 3D printer is difficult to use or is constantly requiring maintenance. “Our Stratasys machines are basically hands off/lights out manufacturing and require very little input to keep running. I can train anyone in the shop to set up and run the machines and they are off to the races the same day with zero issues.”

“If the 3D printed idea works – great! If not, make a quick iteration and print again. Continuous improvements are fast and simple with little cost, time or risk.”

Ryan Bocook, Manufacturing Engineer, BOOM Supersonic
Bloodhound goes into administration

BLOODHOUND PROGRAMME LTD, the company behind the project to get a car to travel at over 1000mph, has gone into administration after running into a financial roadblock. The Bloodhound supersonic car (SSC) is built and has been tested to 200mph but needs a £25m investment to get to the final phase.

The administrators, FRP Advisory LLP, have already begun to talk to potential suitors and want to hear from others. But without the funds the project could be wound up in the coming weeks.

Andrew Sheridan, from FRP Advisory, said: “Whilst not an insignificant amount, the £25m Bloodhound requires to break the land speed record is a fraction of the cost of, for example, finishing last in a F1 season or running an Americas Cup team. This is an opportunity for the right investor to leave a lasting legacy.”

The track on which Bloodhound is intended to break the land speed record is also ready to host the car and, significantly, the Nucleus rocket – three of which would be added to the Rolls-Royce EJ200 Eurojet engine that would push Bloodhound through the sound barrier – was successfully tested in September.

Mark Chapman, chief engineer, Project Bloodhound, added: “With the right support we have no doubt that the project will achieve its aims and could be racing for the record in as little as ten months.”

SOLUTION TO LAST MONTH’S COFFEE TIME CHALLENGE

The solution to last month’s problem of designing a device that allows arthritis sufferers to operate fiddly things like keys comes from a designer called GeoffRolandsen. His solution, the Keywing, was born when he saw his father, who lives with arthritis, struggling with his keys.

The Keywing is a small, light assistive device that clips onto the head of a key to create a larger more ergonomic surface area, essentially forming a handle that’s easy to turn and hold.

It can be kept attached to a keyring or even just left on a key without becoming too big to slip into a pocket or a bag. But, crucially it provides piece of mind for its user and gives them back their independence.

This was just one in a range of products and concepts developed by young engineers through the Department for Business, Energy and Industrial Strategy (BEIS) which is looking to tackle the ageing population issue as part of the Government’s Industrial Strategy.
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THE FUTURE IS T-SHAPED

The complex and multi-disciplinary nature of engineering projects means that a new type of engineer may be required. But how can they be found and developed?

For at least a century, engineering was a profession that featured clearly delineated disciplines. A mechanical engineer was distinct from an electrical engineer, who was in turn distinct from an electronic or civil engineer, etc, etc. These delineations were, and remain, reflected in the alphabet soup of engineering institutions that exist in the UK – IMechE, IEE, ICE and so forth.

Of course it has never been quite as clear cut as all that. Different disciplines have always had to cross over on certain projects and polymath engineers have always existed. However, for many years it was a rule of thumb that engineers tended to remain within their specialisms for most of their career.

More recently, however, these boundaries have begun to erode. The increasing complexity of projects has meant that levels of collaboration have had to increase, followed inevitably by greater cross-disciplinary understanding. Equally, as demand for engineers has increasingly come to outstrip supply, there has been a concomitant requirement for existing engineers to master technologies outside their traditional comfort zones.

This has led to the rise of what is known as the ‘T-shaped engineer’. The idea of T-shaped skills was first mentioned by David Guest in a 1991 article discussing the future of computer jobs, and then championed as an approach to hiring the right talent in order to build inter-disciplinary teams that can come together to create new ideas.

Essentially, the T-shaped concept is a metaphor for the depth and breadth that an individual has in their skills. The vertical bar on the ‘T’ represents the depth of related skills and expertise in a single field, whereas the horizontal bar represents a breadth of skills and the ability to collaborate across disciplines with experts in other areas and to apply knowledge in areas of expertise other than one’s own.

For engineers, this means not only possessing deep, technical skills, but also having broader attributes—such as empathy, communication skills, teambuilding, and the ability to collaborate – or ‘soft skills’. Increasingly, such skill sets are seen as necessary.

One enthusiastic advocate of an increasing emphasis on such multi-disciplinary skills is Pete Lomas, the designer the original hardware for the Raspberry Pi and director of systems engineering at electronic design and manufacturing SME, Norcott Technologies.

“I think now, as an engineering society, we’re looking for T-shaped people, who have a breadth of knowledge, but also a depth of knowledge in one particular
PETE LOMAS

Pete Lomas’ career started aged 13 when he re-purposed a telephone relay rack into a noughts & crosses ‘computer’ igniting a lifelong passion for engineering and digital making.

Today he is engineering director at Norcott Technologies, a provider of electronic design and CEM services. His role keeps him close to the ‘coal face’ of engineering and product design in areas as diverse as fire detection, X-ray imaging, nuclear physics and the Internet of things.

Pete takes a holistic approach to design and production to ensure that creative design does not get swamped in manufacturing technicalities and product viability is not compromised by “specification-creep”, cost overruns and delayed market launch.

Pete has always had a passion for education mixed with a concern about the visibility of engineering when children are choosing career paths. In 2008 a perfect opportunity arose at a meeting in Cambridge and the Raspberry Pi Foundation was formed.

Pete took early responsibility for the hardware design and manufacture of the Raspberry Pi computer. Handing it over to an internal design team in 2014 allowed him more time to focus on his role as a trustee and volunteer. Raspberry Pi has become a global phenomenon with sales of 20 million devices and a team of over 80 delivering its mission: “To put the power of digital making into the hands of people all over the world.”

specialism,” he says. “Projects are no longer just about electronics, or mechanical engineering or pouring concrete. They have a cross-disciplinary aspect to them. For instance, buildings in downtown Tokyo have earthquake countermeasures that involve structural design, mechanical actuators and computer control systems all working in harmony to provide a solution. Lomas believes that this type of engineer increasingly represents the future of the profession, something he is keen to encourage via his role as the honorary president of the Institution of Engineering Designers.

“I’m seeing lots of exciting developments coming up but in the main all the really game changing products going to be created by these cross-disciplinary teams.

On the question of how cross-disciplinary engineering can work in reality, Lomas says: “I can’t speak for industry in general, but I think they understand the value of bringing cross-disciplinary teams together. And if you think about it, industry has been doing this thing they call concurrent engineering for years. It’s not really that different, but the key difference is that you have someone at the helm with a good breadth of understanding of the whole project. How many products do you see where the engineering concept is brilliant, but the final solution leaves something to be desired, so the product goes nowhere. It really needs all those facets to be brought together to make a world-beating product.”

Lomas is keen, however, to point out that he doesn’t foresee an end to single-disciplinary engineering. “If you’re an out and out electronic engineer and that’s what you are passionate about then that specialism is equally valid and critically develops the state of the art in that discipline,” he says. “However, particularly in SMEs like here at Norcott, I need what I call ‘cross-threaded people’. I’ve have an electronics engineer right now tinkering with a SolidWorks model of a group of mechanical components to see if we can get them to fit together in a better way with the electronics.”

This requirement comes about because of the increasing demands from customers wishing to optimise the integration of all aspects of a design. Says Lomas: “So he’s got the ability to model the mechanics and the electronics in parallel and see optimisations across the disciplines. The number of times people have come to me and said: ‘Here’s beautifully designed enclosure, now we just want you to put your electronics into it’ – and vice versa. That’s not how it can work anymore, if ever it really did! You need a lot of 3D modelling to give the customer the look and feel of the end product to their look and feel of the end product...
and validate everything will fit before we release it for prototyping, and SMEs need people with the skills to do that, it’s integrated product design.”

The question that arises, then, is where such people can be found? Here things become much more complex. While industry may be increasingly open to the notion of the ‘T-shaped’ engineer, and many grow into ‘T-shaped’ through necessity, the education remains stubbornly predicated on the older, much more clearly delineated paradigm in which different specialisms ‘stay in lane’. While industry may be in favour of the idea, when asked whether he believes engineering education caught up with that idea yet, Lomas is succinct: “I wish.”

The problem, he believes, is that education is not yet properly equipped to meet the demands of the employment marketplace. “There’s no doubt that education is suffering from a lack of funding, but the other dynamic that’s also difficult is the speed with which it can change. Our educational system lags far behind the jobs and roles that our society demands. New roles are developing faster than our education system can react. That’s not a criticism; it’s unfortunately a structural issue that needs to be addressed.”

Is this something he feels he can help address in his new role with the Institution of Engineering Designers? “I’m not pretending for a minute that I’m going to make a massive impact, but I do hope to make some difference. The critical thing underlying all this is if you look at the engineering pipeline. It starts off quite promisingly, but then it gets whittled away and by the time we get to graduates looking for jobs, it’s a very small percentage of the number who originally started with an interest in their early school years. It’s been recognised that signposting the varied and exciting opportunities in engineering is critically important. Coupled with that we need an educational system that develops young people to be inquisitive, engaged, collaborative, resilient and sufficiently agile so they can confidently pivot into new opportunities as they arise.”

In his role with the Raspberry Pi Foundation, Lomas has devoted no small amount of his career to improving this situation, of course. Much of the thinking behind the Raspberry Pi was to make computer science and engineering accessible and comprehensible to children through demonstration. He says: “Keeping the Raspberry Pi without a case so that you could see its components was as close as we could get to showing children how it actually worked. More importantly for me as an engineer was that you could then attach LEDs and switches to it and with a small amount of code demonstrate, for example, how a set of traffic lights works.”

This model of learning through demonstration is rooted in his past. He says: “I was absolutely useless at school – I hated it. It wasn’t until I went to a technical college that things changed. The thing that did it for me surprisingly wasn’t electronic, it was a Pelton wheel. Being face to face with the actual device and being able to change parameters, more water, turned those dry equations into something tangible.”

This logic, he believes, can be carried through to encouraging the development of T-shaped engineers by encouraging the sort of projects in which they can thrive and by making them aware of the possibilities. As he puts it: “We need to give engineers the opportunity to get involved in all aspects of a project, and also time to learn and develop those new skill areas and become that ‘T’ shaped person.”
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In an industry where change is slow and painstaking, any aircraft innovation is hot property. But by concentrating on protecting their IP, companies miss out on learning from each other and producing more successful designs.

This is why Airbus and Rolls-Royce are breaking the mould by working on many of their biggest R&D projects in the same building. This has opened up new kinds of collaboration.

For example, the two aerospace giants are now able to work together in areas where engine and airframe makers have traditionally not agreed. These have included the thorny issue of what information pilots really need to be given on the aircraft performance, leading to unnecessary strains on engines and more maintenance needs; and a project using a full-scale A320 wing to test for the most efficient engine positioning; and test rig to provide data and models as the basis for any futuristic aircraft designs.

This process originally came about when Airbus and Rolls-Royce bosses said their engineers will work closer than ever before after the opening of the Aerospace Integration Research Centre (AIRC) at Cranfield University. In fact, heads of the companies hailed a “new paradigm of collaboration” when they officially launched the £35m research centre.

Research in the centre includes work on unmanned aerial vehicle (UAV) flight patterns, fibre-optic sensing technology for helicopter blades and automated manufacturing of aeroplane parts.

“The word collaboration is absolutely key for everyone involved,” says Cranfield director of aerospace, Iain Gray. “It’s looking at how you work together... to meet environmental goals, to meet logistics goals, cost and performance value.”

Researchers, some of whom are pilots themselves and can test technology in-flight by taking off from the adjacent airport and work alongside engineers from the partner companies in the centre.

Funded by Airbus, Rolls-Royce and Cranfield University, following an award from the Higher Education Funding Council for England (HEFCE), the Centre will be a flagship facility for boosting aerospace research capabilities in the UK, cementing the University’s reputation as the leading aerospace research institution in Europe.

Researchers from both the University and business partners, including Airbus and Rolls-Royce, will work under one roof. The Centre will be researching ways of integrating advanced technologies to reduce the time from academic innovation to industrial application.

To enable this, the AIRC is equipped with the latest cutting-edge aerospace research technology including air traffic management (ATM) and unmanned aerial vehicle (UAV) laboratories; flight simulators; a virtual wind tunnel; a Fanuc robot in the intelligent automation centre; and a 1500m2 open space work area, currently housing a full-size wing from an Airbus plane.

Professor Sir Peter Gregson, vice-chancellor and chief executive, Cranfield University, said: “Facilities such as the AIRC mean Cranfield is at the forefront of changing the way the world thinks about flight. Greater integration between research and world-renowned businesses provides us with the opportunity to tackle some of aerospace’s grand challenges by providing the technologies, facilities and skills that are needed to succeed.”

Trevor Higgs, head of landing gear and UK senior site representative, Airbus, said: “We at Airbus see the AIRC as a key part of the growing research ecosystem the aerospace industry has in the UK, and will help us foster closer relationships with research partners and to accelerate and deliver on our research strategy for the Wing of Tomorrow, to make sure our
products remain the best in world.”

Henner Wapenhans, director of technology strategy, Rolls-Royce, added: “We are delighted to be a lead partner with Airbus in the Aerospace Integration Research Centre, which will also strengthen the existing strategic partnership between Rolls-Royce and Cranfield University.

“This new Centre will help develop the next generation of highly skilled engineers and will play an important role in developing the innovative technologies needed to enhance performance, improve efficiency and reduce emissions of future aircraft.”

David Sweeney, director (research and knowledge exchange), HEFCE, said: “The AIRC is an excellent example of the government’s industrial strategy in action, linking research to industry needs which is what the UK Research Partnership Investment Fund supports. The high-class facilities and the world-leading research at Cranfield University will contribute directly to the growth of the aerospace industry and the wider UK economy.”

Cranfield is the only university in Europe that brings together major aerospace research facilities such as the AIRC, an operational airport and runway on one connected site.

One of the AIRC’s unique features is its focus on integration, where new aerospace technologies are rapidly developed and tested for current and future aircraft and airspace concepts.

This is supported by centre-based facilities including visualisation screens that enable the development time from idea to implementation to be shortened. It has laboratories dedicated to aerial autonomous vehicles and engineering photonics. Its 1500m2 Open Space laboratory enables research on full-scale aircraft and components, and currently includes a production standard A320 for research and validation of automated assembly techniques being developed in the Centre. It also has covered laboratories dedicated to aerial autonomous vehicles and engineering photonics applications.

Research at the AIRC also draws on the full capabilities of Cranfield University, including its on-site airport, National Flying Laboratory Centre, large scale gas turbine test area and Cranfield’s School of Management. This allows researchers to take their projects from theory to flight demonstration in one place, validating their research to technology readiness levels (TRL) 6-7 – higher than the levels normally associated with an academic environment.

The AIRC cost £35 million

Professor Iain Gray leads the aerospace capabilities across the University and their strategic relationships with the world’s major aerospace industrial organisations. Iain was chief executive of Innovate UK (formerly known as the Technology Strategy Board) until he joined Cranfield in March 2015.

Professor Gray has 27 years’ industry experience in the aerospace sector including roles at British Aerospace and BAE Systems. He held various engineering positions before taking on the roles of director of engineering, then managing director at Airbus UK. He became the first chief executive of Innovate UK following its establishment in 2007.

Professor Gray completed his early education in Aberdeen, culminating in an Engineering Science honours degree at Aberdeen University. In addition, he gained a Masters of Philosophy at Southampton University in 1989. Since then Iain has received Honorary Doctorates from Bath, Bristol, Aberdeen, Aston and Exeter Universities in 2005, 2006, 2007, 2011 and 2012 respectively.

He is a chartered engineer, a Fellow of the Royal Academy of Engineering and a Fellow of the Royal Aeronautical Society and was awarded the Royal Aeronautical Society Gold Medal in 2007. He was elected as a Fellow of the Royal Society of Edinburgh in 2011.
NEW PRODUCTS

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A utomotive companies are under pressure to meet stringent emissions targets, and the contribution of design engineers will be crucial in achieving this. Factors such as improving engine performance and creating a sleeker, more aerodynamic chassis are usually cited as major factors in the drive towards improved fuel efficiency, but another critical – and ongoing – issue is lightweighting.

Lightweighting underpins nearly everything that automotive companies are trying to achieve. Stripping weight helps improve power to weight ratio and allows extra features such as enhanced cabin protection or more extensive control systems to be introduced without affecting fuel efficiency.

“Design engineers can select from a wide range of materials, encompassing advanced metals, engineering plastics and composites,” says Antonio Pagliuca, senior technical specialist adhesives for 3M’s Automotive and Aerospace Division. “The trick is to select exactly the right material for each application.”

One way to do this, Pagliuca continues, is to create hybrid structures, where components made from different materials are combined into a single product. For example, a front-end module, which incorporates components made from several different materials.

While this approach maximises the inherent advantage of each material, there is still a challenge to overcome: how to fix them together without affecting structural integrity or the characteristics of each material. Historically, this has been done with rivets and fasteners, but is increasingly being achieved using structural adhesives.

“According to a study in 2017 from the Center for Automotive Research (CAR) in the USA, the use of mild steel for body in white will plummet from 55% today to just 5% in 2040, as it is replaced by stronger, lower-density materials such as aluminium and polymer composites,” says Pagliuca. “Such mixed material designs are increasingly held together with adhesives: research from CAR reveals that some vehicle models use more than 10 times more adhesive than they did in 2001, due largely to the use of mixed materials. According to CAR, adhesives will become the dominant form of joining by 2030.”

Pagliuca claims that the use of adhesive-bonded mixed materials can make a double contribution to lightweighting: modern advanced materials such as composites have lower densities than those they are replacing (such as mild steel), while the preferred method of joining them (adhesive bonding) removes the need for bolts and rivets – further cutting body weight.

“Using structural adhesives also overcomes some of the potential downsides of combining mixed materials – such as preventing galvanic corrosion between dissimilar metals,” he adds. “At the same time, the cleaner look of bonded joints (compared with mechanical fasteners) creates better looking, more efficient product builds without the need for extra finishing work, so streamlining production.”

ADHESIVE ADVANTAGES
As the automotive industry uses more and more mixed materials.
ADHESIVES | LIGHTWEIGHTING

Adhesives will continue to grow in importance, and the increasing popularity of polymer composites exemplifies their advantage.

It is possible to join polymer composites to other materials using traditional mechanical attachments such as clips and screws. However, it requires an extra step to mould or create features for the attachment, which can create stress concentrations, leading to cracking and premature failure. Drilling holes in composite materials will reduce strength by introducing discontinuities into the matrix and reinforcing fibres. To add to this, any mechanical attachment method will add weight to the structure. Non-mechanical techniques such as heat and friction welding can be used for some composites, but these are energy- and tooling-intensive and have limitations in the possible geometries and substrate combinations.

Just as there are many different types of polymer, so there is a wide variety of adhesives, such as epoxies, acrylics, and urethanes, that allow design engineers to create products that meet structural integrity requirements. These structural adhesives work with multiple substrates, including plastics, metals and composites, without losing performance properties. Even low surface energy plastics such as polypropylene and polyethylene, which are difficult to join, can be bonded with the latest generation of speciality structural adhesives.

As well as forming strong bonds, structural adhesives can lower overall costs, increase product durability and make a significant contribution to lightweighting. Durability is improved because adhesives distribute stress across the bonded area, while fasteners, rivets and spot welding can create stress concentrations – leading to weak points across the substrates. Adhesives also seal the entire bonding area while providing a high strength joint.

GOOD EXAMPLES

A few examples of where structural adhesives have successfully improved design and manufacture in the automotive sector show the range of potential applications.

In one example, a manufacturer used adhesive bonding to attach Acrylonitrile Butadiene Styrene (ABS) inserts to a glass-filled polypropylene bumper. It was the only way to provide good adhesion and a permanent structural bond to both surfaces without pre-treatment that also maintained the required surface appearance.

Similarly, adhesive bonding is routinely used to attach interior trim panels such as bonding a large thermoplastic bulk head to an external aluminium frame.

And it’s not just for mass-produced cars. Speciality vehicles such as buses and coaches can also benefit. In one case, a polyurethane adhesive sealant was used to bond a glass-reinforced plastic side panel to a coated steel frame. The adhesive withstood the loads applied to the panel during use and allowed for the necessary movement created by the vibrations and differential thermal expansion.

“Many designers may feel that a line of adhesive can never be as effective as a line of rivets,” says Pagiuca. “However, many tests and practical examples show that adhesive bonding can outperform mechanical fastening techniques: As well as cutting part count and component weight, adhesives can seal gaps, reduce internal vehicle noise and act as the best interface between a wide range of dissimilar materials.”
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DESIGN · DEVELOPMENT · PROTOTYPING · MANUFACTURE
Even for relatively simple manufactured products, there is more to inspection than meets the eye. Manufacturers must consider accuracy, reliability, cost, speed and where in the process to carry out the measurement. The requirements vary across industry sectors. Volume production usually relies on a sampling inspection strategy, so automotive component producers, for example, typically measure a few parts from each batch to help ensure consistency. Safety-critical applications normally require 100% inspection, so aerospace manufacturers usually inspect each part individually and maintain records for the long term.

“With the dawn of Industry 4.0 comes the rise of smart manufacturing technologies that are bringing complexities to the inspection process,” says Phil Hewitt, manufacturing product manager, Autodesk, who has been working with FARO Technologies on smart metrology in additive manufacturing. “Yet they can’t be ignored, since they’re integral to the future development of smart factories, more efficient manufacturing and customised products – and will help boost manufacturing the world over.”

Indeed, according to a new study carried out by Accenture, Industry 4.0 could add as much as $14.2 trillion to the global economy by 2030, driven by smart factory solutions.

So, how can manufacturers update their inspection processes for smart manufacturing?

“The purpose of smart factory metrology is to give manufacturers greater visibility of the whole supply chain, including suppliers,” Hewitt explains. “Smarter, quicker, actionable metrology is an important foundation of the future factory. A factory equipped with industrial robots and automated material handling relies on automated control systems built on timely verification and feedback.”

However, Hewitt adds that interconnectedness requires more visibility and better data flow, and this requires interoperability. As a result, manufacturers need to adapt their inspection processes to overcome physical barriers, as well as close the gaps in metrology information between different stages of the value-chain to fully support customised, digital and autonomous production.

With the rise of Industry 4.0, it’s never been more pressing for manufacturers to adapt metrology to the needs of the smart factory and the technologies within them. Here are three processes Hewitt says they should be considering:

1 **Inline metrology**

For manufacturing operations, inline metrology (measurements carried out as part of the process) has several advantages over traditional methods, where inspection is a separate activity.
Speed of decision making is crucial. Moving the parts to an inspection department requires additional transport and setup operations which can result in delays. Inline inspection saves time and allows some of the process steps to be removed. Measuring parts in-process can help reduce rework and scrap, as detecting problems sooner helps prevent problems from going unnoticed. Inline inspection also provides the opportunity to minimise the impact of any rework – it is much easier to correct a problem while the part is on the machine. Taken to its logical conclusion, in-process measurement can help prevent problems from occurring in the first place. If variation is detected early enough, it is sometimes possible to take corrective action to compensate for the variation before it becomes a problem.

2 Non-contact: optical and laser systems
Non-contact metrology, including laser scanners, phase-based laser scanning and optical systems, are crucial to smart factories. Non-contact measurement allows high-resolution scanning of parts and long-distance manoeuvring of measuring devices. However, these methods are not without their challenges. Non-contact metrology typically has line-of-sight limitations and requires accurate positioning to measure detailed features such as holes and sharp edges. The Metrology Hub at the University of Huddersfield is working to increase the technology’s capability for high dynamic range measurement. This aims to improve the ability of metrology to measure workpieces effectively from a distance while maintaining the capacity for very high levels of accuracy.

3 Robots
Accuracy, reliability and continuous production are all well documented benefits of introducing robots into a factory. And while robots are not designed to measure parts, they can be optimised for use in inspection, especially high-volume productions, with 3D measurement and metrology software such as Autodesk’s PowerInspect. The sweet spot for robotic inspection is the 100-micron tolerance area and above. Here, errors of a robotic machining system can be compared with a normal machine tool in a fair comparison.

THE RISE OF SMART INSPECTION TOOLS
The science of inspection is evolving rapidly, alongside other fields in the Industry 4.0 revolution. For example, EU-funded and multi-partner project, SYMPEXITY, was launched to research and improve how humans and robots collaborate, specifically in polishing. They found that 90% of finishing work is done by hand, but robots could shift the balance nearer to 20%, with the rest done by robots under human supervision.

“Evaluating polished surfaces is difficult, and many surface finish parameters have evolved to cover different conditions,” says Hewitt. “The SIR Cell employs a surface finish sensor to measure surface quality; it can report on as many as 13 data parameters. Humans, however skilled, inevitably end up having to make subjective judgments on whether the finished part is good enough.”

According to Hewitt, one of SYMPEXITY’s offshoots is developing the means to see surface-quality data using augmented reality (AR). “AR could mean the end of flat 2D representations on screens. Rather than trying to visualise how a certain parameter change might affect the part, the information is presented directly on the surface.”

This is said to help remove some of the subjectivity so that users can make more informed decisions more quickly. It is expected that a human expert will approve the results for the foreseeable future, but when measurements of properties are quantifiable, the data can be connected directly to the quality assessment process.

Beyond research, suppliers are also developing new technologies with better measurement capabilities, and manufacturers must embrace these new methods to keep pace with competitors.

Hewitt says: “Better measurement will help reduce downtime, speed up production, and lead to more accurately designed products, as well as support the evolution of truly interconnected factories. With smarter and possibly more affordable measurement tools set to emerge in the next 12 months, now is the time for manufacturers to step up and update their inspection processes.”
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Additive manufacturing is transforming business across industries. Even a 125-year-old lighting company is using it to reduce failures.

A true ‘life essential’, lightbulbs are required in vast volumes, yet their fundamental design necessitates precision assembly of delicate materials. Add to this the harsh realities of repeated furnace heating and rapid cooling; the wear and tear of continuous production and the absolute need for quality control, and it is clear to see that there is more to manufacturing the humble lightbulb than meets the eye.

What if this process could be simplified? What if the assembly-line itself could epitomise the concept of ‘innovative thinking’ synonymous with the end product? Materialise and Philips Lighting decided to find out by utilising 3D printing. The collaboration has already resulted in the ‘reinvention’ of a lamp holder previously prone to part failure, and the automation of a previously labour-intensive line using lightweight design. Just these two uses together are realising cost savings of around €89,000 a year through the operational benefits they deliver.

KICK-STARTING THE CO-CREATION PROCESS

The Philips Lighting site in Turnhout, Belgium, plays a key role in maintaining a tradition that stretches back to 1891 and is widely recognised as a trendsetter in the field of professional lighting technology. In fact, Philips Turnhout often works in partnership with research centres based in Belgium and beyond on innovations in the field of high-pressure gas discharge lamps, from concept to production.

Interested in the potential that 3D printing – particularly metal printing – could help unlock in its production process, Philips Factory engineering designer, Danny Van der Jonckheeyd and his team invited 3D printing solutions and service provider, Materialise, to the site to gain an in-depth understanding of Philips’ specific production line requirements.

Sven Hermans, business development manager at Materialise recalls: “You have to see a line in action to truly appreciate the demands, strains and stresses on specific assembly elements, but also to understand the pressures on personnel. While at the site, we looked at parts and spoke with production line operatives, maintenance teams, factory engineers – as many people as we could in order to identify issues and areas ripe for enhancement that would be ideally suited to 3D printed solutions.

‘Where could the option to use lighter materials have an impact? Where could structural design, impossible or too expensive to realise using traditional manufacturing techniques, be used to improve performance or reduce wastage? These were the types of questions we worked on with the team at Philips.”

PRINTING TO PREVENT PART FAILURE

The first part earmarked for improvement was a bracket/holder used to hold lamps in place and keep lead-in wires away from heat.
as torches are applied to melt and seal off glass exhaust tubes. Repeated exposure to high temperatures on a continuous line, paired with a structure featuring weld lines from a four-piece bracket assembly, meant sheering and breakage was a common occurrence, with one or two failing every week.

The brackets could be and were being repaired on site using a buffer supply of spares Philips had to store on location. However, each multipiece unit was difficult to remove and disassemble – heat-expanded screw points being a particularly troublesome issue – and could take up to two hours to fix. Also, only a limited number of repairs could take place before a completely new unit was needed, requiring a lead time of approximately eight weeks.

Working in partnership with Van der Jonckheyd’s team, Materialise co-engineered and metal printed a new single structure bracket, reducing time-consuming part assembly and removing weld line pressure points completely. In the first three months of use, the re-imagined bracket did not break once. It is a small change that has made a significant difference.

“Van der Jonckheyd explains, “We thought having to fix parts less often and more easily would be the biggest advantage, but so far we haven’t had to replace any.”

Even when looked at purely in terms of reduced maintenance technician time, Philips is already saving around £3,000 a year. This also means the technicians can concentrate on other technical problems. Additionally, fewer breakages means that replacement part outlay has been reduced, and because ‘digital spares’ can be printed and delivered in just 10 days, only a limited number need to be stored on location.

“The previous brackets required frequent cleaning to ensure fraction grooves weren’t forming – caused by wire thread-through – that could damage our end-product,” Van der Jonckheyd continues. “They had to be removed from the line in order to be maintained in this way which was time consuming. 3D printing has enabled us to create new conical wire holders as part of the bracket, with internal channels that require much less cleaning and allow in-situ maintenance.

“But I’d say the biggest difference has been the impact this has had on the mindset of those who work here. It’s sparked a thought in everyone that we can and should do things differently – since this initial project I’ve been approached by people from different aspects of production with ideas for other ways 3D printing can work for us. It’s truly engaged our workforce.”

**LESS LABOUR, LOWER WEIGHT, LEANER CYCLE**

Testament to this new mindset, as the lamp bracket underwent development the production team at Philips spotted another opportunity. Could 3D Printing help with the automation of an existing, highly labour-intensive process?

The line in question previously required a machine operator – in continuous attendance – to physically place parts in a 12-bore gripper, apply materials and remove finished units. Automation of this process required enhancements to the vacuum suction capability of the gripper and a lighter construction still sturdy enough to withstand the strains and stresses of a ‘pick and place’ robotic action.

Van der Jonckheyd’s team knew that 3D printing represented huge potential in terms of alternative metal materials, textures and internal structures that could provide a solution and worked with Materialise to design and print a part to test. By consolidating construction (reducing the need for as many individual parts), creating curved internal channels and printing the gripper from aluminium, strength and suction has improved while reducing overall unit weight.

“The gripper’s new capabilities have removed the need for time consuming manual part placement which, over the course of a year, will save us around £80,000 and significant operator hours,” says Van der Jonckheyd. “On top of this, the speed facilitated by the reduced weight means cycle time has reduced while production has increased. The whole process has really opened our eyes, imaginations and hearts to 3D printing to such an extent that it has become a natural component of our manufacturing toolkit.”
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By reintroducing the iconic shapes of the Sixties into an entirely new and contemporary package, the project was part of a six-month development programme called the E-MINI Classic proof of concept project. This was part-funded by the Niche Vehicle Network, an independent association of over 900 niche vehicle manufacturers, specialist technology and design and engineering companies.

The project was announced in 2017 with the intention of bringing together expertise in vehicle systems and electric powertrain engineering with battery technology to create a small fully electric vehicle for use in urban environments. The work was undertaken by consultancy SDT Drive Technology alongside two UK partners; Swindon Powertrain and battery specialist MEP Technologies. SDT Drive Technology accelerated development, pushed designs in the right direction and helped towards the goal of creating a custom, compact and efficient powertrain.

SDT specialises in the design, development and supply of advanced electric rotating machines and drives for many industries including automotive, aerospace, appliances, industrial, medical/rehabilitation, oil & gas, leisure, mobility, pumps & air movement, rotating equipment and renewables.

The consultancy plays a key role in selecting affordable, efficient, stable and reliable custom electric powertrain technologies in compressed time frames. Its primary focus is the process of defining, evaluating, designing and incorporating technologically advanced custom high-speed motors, gearboxes and controllers – that provide better solutions in meeting system configuration and vehicle operating requirements.

To achieve this, as things become smaller and more power dense, it became essential to address component integration issues from the very first stages, and validate high-speed motor concepts to reduce space requirements and weight to fit into a MINI vehicle. High-speed traction motors have significant potential for the reduction of weight and size, but normally have less torque capability. Thus a custom gearbox was needed in order to keep the acceleration performance of the vehicle as high as possible.

This MINI vehicle programme uses a single in-board high-speed brushless drive configuration to propel the driving wheels. The traction motor and drive assembly is located in the front of the vehicle. However, a single inboard motor, gearbox, and drive shaft was easier to use, and was proved to be a cost-
The MINI is powered by one electric powertrain drive which provides a maximum power output of 85kW alongside a maximum speed of 120km/h. The concept was designed and approved by producing a demonstration prototype vehicle and further testing is currently underway.

The MINI vehicle concept was in development for almost six months, the mission is to create safer and more environmentally-friendly technology. The challenge was to provide a compact, efficient electric powertrain vehicle system while ensuring performance and meeting automotive standards in a short period of time. The answer to this was components: “Identifying the right calculations and including appropriate simulations in the initial stages means you can see what works and highlight potential problems earlier,” according to Dr Sub Safi, the founder of SDT Drive Technology.

Today, there is continued commercial interest in these classic vehicles and on successful conclusion of this project, the vehicle is now ready for Production Readiness Stage, to continue to build upon the successful results achieved so far by the current proof-of-concept model.

SDT Drive Technology believes that the results of this MINI concept programme show that E-MINI Classic concept technology will enable an electric vehicle market in the near future and will help to expand this market. In addition, it is hoped the technology will also enable electric vehicle volume production and will allow these classic vehicles to continue to be used in cities that prevent old, high-emission vehicles from urban areas.

The MINI is powered by one electric powertrain drive which provides a maximum power output of 85kW alongside a maximum speed of 120km/h.
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UK-based aerospace technology company Derwent Aviation has developed an aero engine architecture which, it claims, will halve nitrogen oxide (NOx) emissions and deliver significant benefits in cost of ownership. Derwent also says it lends itself to the further electrification of commercial aeroplanes and could be available to operators by 2025.

The ‘Dual Drive Booster’ (DDB) is currently being developed by industry performance analysis experts as well as university research centres in the UK and Germany.

Charles Cuddington, Derwent’s chief executive and former managing director of Rolls-Royce’s civil engines business, says the DDB concept can deliver major benefits to a variety of applications, in particular “more-electric” and hybrid aircraft.

“We are excited by the potential of the DDB. Now we’re looking to the leading manufacturers with their resources to join us in taking the project to the next level,” he says.

In a conventional two-shaft aero-engine, the booster compressor is directly driven by the low-pressure (LP) shaft, which limits its rotational speed. The DDB transforms the performance of the booster compressor by driving the booster from both the LP and high-pressure (HP) shafts, improving its efficiency along with other engine cycle benefits. This involves an epicyclic gearbox in which the LP and HP shafts provide the input while the output drives the booster compressor.

“On a medium-thrust engine like the CFM International Leap, the new booster-generator configuration could extract 2MW of electrical power,” Cuddington says.

“Combined with batteries on board the aircraft, the electrical generator/motor layout could be used to provide power assistance for take-off and climb.”

Using like-for-like comparisons of narrow body (single-aisle) aircraft operations, Derwent’s projections anticipate the DDB hybrid application will cut NOx by up to 50% and result in fuel burn benefits of 3-4% for flights of up to 1000 miles, which covers 85% of all flights. However, Cuddington notes, the battery configuration would not be suitable for long-haul flight as the equipment’s weight would negate any fuel efficiencies. Derwent is also in the process of quantifying reductions in maintenance costs resulting from the lower turbine operating temperatures made possible by the new booster. Cuddington says the DDB concept can be “tuned” to shift the balance between NOx emissions and fuel efficiency, and that he is confident the layout would generate fuel-burn savings similar to the latest generation of engines like the Leap.

He concedes that the new layout would be incompatible with a geared-fan architecture such as that on Pratt & Whitney’s PW1000G and Rolls-Royce’s UltraFan future engine programme. But he says the
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**POWER TRANSMISSION**

DDB would deliver notable NOx emission reductions versus latest-generation powerplants.

Utilising advances in gearbox design, studies have found that the DDB enables significant amounts of additional power to be extracted from, or returned to, the engine. This can be achieved without compromising engine operability, which is not possible in conventional two-shaft gas turbines. Given the likely option for the new booster’s use with more-electric configurations.

Derwent’s development team is also investigating the potential for an embedded generator/motor driven directly by the internal gearbox, which would rule out the requirement for an accessory gearbox, which are currently mounted externally on today’s engines.

Feasibility studies are currently being funded by an Innovate UK grant scheme. This work is being carried out at the University of Nottingham Gas Turbine and Transmissions Research Centre (G2TRC).

So far, the epicyclic gearbox has been shown to be technically feasible but a number of risks have been identified. For example, because the gearbox operates at high speed, there is a risk of high heat generation due to oil churning.

The G2TRC team has generated a computer model of the gearbox to simulate oil and air flows and stress levels in the gears, so that the design can be optimised to reduce this heat generation to a minimum.

The flow simulation required capability which, in the UK, is only found in the G2TRC which provides world-leading expertise in the application of multiphase Computational Fluid Dynamics to gas turbine transmission systems.

The G2TRC team comprises academics from engineering, maths and physics, full-time research fellows, rig design engineers, project managers, ex-Rolls-Royce engineers, and PhD students. The team has verified the loads and stresses of the mechanical design of the DDB and are currently optimising the oil scavenging system.

Dr Stephen Ambrose, project lead at the G2TRC, says: “Within the group we have the capability to run large computational models thanks to our access to the University High Performance Computing facility, which allows us to quickly perform large-scale calculations and analysis.”

Derwent is now beginning discussions with the University to explore the possible involvement of its Electrical and Electronic Engineering Department in future studies of the more-electric/hybrid version of the DDB.

Meanwhile, Derwent is also collaborating with Aachen University in Germany, which has used a modified version of its Gasturb software for performance modelling of the DDB engine, including comparisons with current two-shaft and geared fan engines. The Aachen team has already verified a fuel burn benefit of around 2%. With ongoing testing, it expects this number to increase to the targeted 3–4%.

Derwent has also commissioned the UK’s RAW Aviation Consulting, design and performance analysis experts on future technologies, to create an aircraft performance assessment model for hybrid aircraft.

“There’s a gap between where airplane engines are today and where the industry talks about them being in the future,” Cuddington said. “Nobody talks about what the industry will do while it closes that gap, but the DDB helps fill that void.”

The Nottingham team has generated a computer model of the gearbox to simulate oil and air flows and stress levels in the gears...

![The Nottingham team has generated a computer model of the gearbox to simulate oil and air flows and stress levels in the gears...](image)
Once again, the British Engineering Excellence Awards celebrated the very best in UK design.

October 4 2018 saw a fantastic celebration of the companies and individuals who are flying the flag for this country’s reputation for engineering excellence. Going over and above the expected to achieve excellence is what the BEEAs are all about and you’ll find examples of this in all our awards winners this year. These pages offer a small taste of the occasion.

**CONSULTANCY OF THE YEAR**

**STIRLING DYNAMICS**

Trajan Seymour of Stirling Dynamics receives the Consultancy of the Year award.

**SMALL COMPANY OF THE YEAR**

**TRANSMISSION DYNAMICS**

JR Dynamics was the winner of the 2018 Small Company of the Year Award.

**START-UP OF THE YEAR**

**CIRCUITWORX**

Co-Founders of CircuitWorx Carl Matthews and Robert Steel collect the Start-up of the Year Award.

**MATERIALS APPLICATION PRODUCT OF THE YEAR**

**NYLACAST CHOck LINERT**

Group CEO, Mussa Mahomed receives Nylacast’s Materials Application of the Year award

**ELECTRONIC PRODUCT OF THE YEAR**

**XILINX**

Nick Mehta holding the Electronic Product of the Year won by Xilinx.

**MECHANICAL PRODUCT OF THE YEAR**

**AERISTECH**

Mike Woodroffe collects the Mechanical Product of the Year for Aeristech.
Adam De Grasse of Imagination Technologies receives the Design Team of the Year Award.

David Amory and Rebecca Clubbe of AESSEAL win the Engineering Ambassador of the Year Award.

Brent Brakeboer of Surrey Satellite Technology holding his Young Design Engineer of the Year Award.

Orla Murphy of JLR receives her trophy as Design Engineer of the Year.

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Reducing fuel consumption with lighter landing gear

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Additive manufacturing – is it sustainable?

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**MATERIALS: ROUND-UP**

**WALLWORK INVESTS IN TESTING UNIT**

Metal heat treatment specialist, Wallwork Group, has opened a £130,000 in-house mechanical testing facility, certified by UKAS, at its Cambridge plant.

Andy Fox, operations director at Wallwork Cambridge explained: “Destructive testing is mainly specified by customers in Aerospace, however, it is becoming increasingly common in motorsport, medical devices and other industries where there can be no compromise in product integrity. The new facility gives us much quicker results than going out to an external testing lab.”

The Z100 testing rig from ZwickRoell gives Wallwork the capability to run tensile, compression and hardness tests on materials and components prior to and post heat treatment. This will help to quickly identify any material or processing issues that could impact quality. Fox added: “We are now looking at adding in-house impact and flat tensile testing as part of our continual development process.”

**£7M BOOST FOR VIRTUAL FACTORY**

Developing and testing steel alloys will be made 100 times faster thanks to £7 million of funding from the EPSRC for a ‘virtual factory’ being developed by Swansea University, in partnership with Tata Steel and WMG, at the University of Warwick.

The partnership’s process is called Rapid Alloy Prototyping. Effectively, it means that much of the testing can be carried out in research labs and imaging suites – a virtual factory – rather than in an actual steel plant.

The difference this new approach will make means that 100 samples can be tested in the time it currently takes to test one. These samples can be tiny – only a few grams – whereas current testing can require up to 900 tonnes of material, up to 98% of which has to be remade into new steel products at a cost to the business.

**MATERIAL SHIFTS SHAPE**

A material developed by engineers at the University of Colorado Boulder can transform into complex, pre-programmed shapes via light and temperature stimuli.

Professor Christopher Bowman, of CU Boulder’s Department of Chemical and Biological Engineering (CHBE), said: “The ability to form materials that can repeatedly oscillate back and forth between two independent shapes by exposing them to light will open up a wide range of new applications.”

Previous efforts have used a variety of physical mechanisms to alter an object’s size, shape or texture with programmable stimuli.

The CU Boulder material achieves readily programmable two-way transformations on a macroscopic level by using liquid crystal elastomers (LCEs), the same technology used in television displays. The unique molecular arrangement of LCEs make them susceptible to dynamic change via heat and light.

To solve this, the researchers installed a light-activated trigger to LCE networks that can set a desired molecular alignment in advance by exposing the object to particular wavelengths of light.

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A two-year, £28m project titled ‘Large Landing Gear of the Future’ will see Aluminium Matrix Composites (AMC) manufacturer, Alvant, team up with high-technology group and Tier 1 supplier of systems and equipment to the aerospace and defence industries, Safran Landing Systems. The aim of the project is to reduce landing gear weight by as much as 30% – assisting with the aerospace industry’s drive to reduce fuel consumption and carbon emissions.

The project will look at how AMCs can challenge traditional materials in the design and manufacture of landing gear assemblies, by making use of new materials and manufacturing methods, as well as developing technologies that will reduce fuel burn and noise, while also improving reliability and lowering costs.

Current landing gear systems are typically stronger and heavier than necessary, because an outstanding safety record has resulted in proven techniques being perpetuated. However, they account for approximately 3% of aircraft weight, with a corresponding effect on fuel consumption. Safran believes it is possible to reduce this without diminishing the gear’s capabilities or compromising on safety.

Alvant’s contribution, funded by a £513,000 grant from Innovate UK, will enable the design, manufacture and testing of an AMC brake rod, which will target a 30% weight reduction over an equivalent titanium component, while maintaining a comparable strength to steel.

“A key objective of the Large Landing Gear project is to test and demonstrate as many technology advances as possible,” says Richard Thompson, commercial director of Alvant. “This landing gear component is just one of the many ways in which AMCs can help aerospace firms retain strength while reducing weight.”

**About AMCs**

AMCs are an advanced class of composite materials in which the aluminium is reinforced with a secondary high-performance material, typically a long fibre, short fibre, or particulates, and are suitable for applications where conventional metals are expected to approach or exceed their performance limits. Production-readiness of AMCs comes at a time of increasing commercial demand for strong but lightweight components in many forms of transportation, as well as industrial and consumer applications. Aerospace, automotive, marine and consumer goods manufacturers are all looking for ways to increase product capabilities and performance while simultaneously meeting ambitious goals for fuel efficiency and sustainability.

Compared to unreinforced metals, AMCs have higher strength, greater stiffness, lower weight, superior wear resistance and lower coefficients of thermal and electrical conductivity. AMCs also offer multiple advantages over polymer fibre reinforced materials, such as carbon composites. These include: higher transverse strength and stiffness, a higher thermal operating range, better wear resistance, superior damage tolerance, and easier repairability. This means AMCs can be used to engineer more durable lightweight components for harsh environments.
AMCs claim to offer potential to an industry that needs a step change in performance in order to meet ever stringent market and legislative demands. Significant weight reductions compared to legacy materials offers manufactures the chance to meet the challenge of reduced weight and fuel burn while maintaining reliability and lowering whole-life ownership costs.

According to Alvant, AMCs can have superior strength compared to steel at less than half the weight. This means highly loaded components made from traditional metals, such as steel, titanium and aluminium, can be replaced by lightweight, low inertia parts without any increase in package size.

**Liquid Pressure Forming**

Previously known as Composite Metal Technology (CMT), Alvant was originally founded to explore the potential of Liquid Pressure Forming (LPF), the process for manufacturing AMCs.

The company’s original, primary role was, as a research and development operation, to develop and refine LPF - which ultimately resulted in the creation of the more sophisticated process known as Advanced Liquid Pressure Forming (ALPF).

ALPF is the method by which Alvant brings together aluminium, which acts as the matrix, and a high-strength reinforcement fibre to create a high-performance Aluminium Matrix Composite material.

“Alvant developed and refined Aluminium Matrix Composites during the years when high-tech industries were going through the honeymoon period with polymer composites, such as widely-used carbon fibre reinforced composites,” explains Alvant’s technical director, Gemma Christian. “Nowadays, certain disadvantages with polymer composites are better understood, and Alvant has transformed from an R&D company into the provider of high-strength, low-weight Aluminium Matrix Composites.

“Traditional metallic materials are reaching their limit of use and polymer composites, such as carbon composite, have damage tolerance and thermal operating limits. With this, design and procurement teams are finding there are diminishing returns by specifying these materials in their products.”

According to Christian, companies that will benefit the most will typically be those that are searching to enhance the capabilities of their products, while also respecting sustainability targets. For example, in the aerospace industry, OEMs could benefit from reduced emissions, maintenance, repair and operating costs.

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**Alternative uses for AMCs**

Growing interest in AMCs is affirmed by big-brand collaborative projects and government funding. In the last year alone, aerospace companies Rolls-Royce and Safran Landing Systems and car maker Ford Motor Company, have all engaged in collaborative projects:

- A £1.6m, 30-month R&D project with Ford Motor Company, developing a new casting method for the manufacture of hybrid-AMC components for high-performance production cars. Since the project began in October 2017, £751,000 of grant funding has been awarded by Innovate UK.

- A three-year, £1.2m R&D project under the ‘Make it lighter with less’ competition, run by Innovate UK, and collaborating with GE Aviation, electric motors and controllers producer YASA Motors, and the National Composites Centre. This project created new computer aided engineering (CAE) software modelling packages for the design and analysis of AMCs to reduce product development lead times.

- A £7.9m four-year collaborative project to bring AMC technology to production readiness in April 2018, which included £1.9m of funding from the Government-backed Advanced Manufacturing Supply Chain Initiative (AMCSI).
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3D-PRINTED PROTOTYPES AVAILABLE
As the medical device industry continues to grow rapidly, manufacturers must contend with a variety of challenges if they wish to differentiate products in a highly competitive market. With this in mind, greater emphasis is being placed on the functional coatings that are applied to stainless steel, titanium and other substrates of critical medical devices from implants to scalpels, needle drivers, bone saws, and reamers.

When manufacturers first began coating instruments, the primary purpose was to improve the aesthetics of instruments and improve identification during surgery. Titanium nitride, with its easily recognisable gold colour, quickly became the coating of choice for this purpose.

However, OEMs are now looking to move beyond aesthetics by applying titanium nitride and other innovative PVD coatings to improve wear resistance, reduce galling between sliding components, increase lubricity and even help retain sharp edges on cutting instruments.

These same coatings can also deliver other important functional benefits, such as providing anti-glare surface for bright operating rooms, antimicrobial properties and anti-fouling in the presences of blood and tissue. In some cases, it can even potentially turn devices into multiple re-use items, for example with laparoscopic instruments.

One option medical device manufacturers often consider for adding functional value to medical devices is medical-grade PTFE. Although this type of coating is known for its low coefficient of friction, it is not recommended for high load applications because it is relatively soft and can wear away or experience micro-fracturing under high loads.

Another alternative is anodisation, an electrolytic process that coats the metal substrate. Unfortunately, it is impossible to effectively anodise stainless steel without losing wear resistance and durability, which is a significant disadvantage.

Moreover, anodisation can form a layer of rust on the stainless steel, causing it to corrode. For this reason, anodisation is typically only used on aluminum or titanium. This limits the range of medical devices that can utilise this type of coating.

To overcome these challenges, medical device manufacturers are increasingly turning to physical vapour deposition (PVD), a process that describes a variety of vacuum deposition methods that can be used to produce extremely hard, thin coatings on stainless steel, titanium, ceramics and other advanced materials.

These coatings provide a unique combination of extreme surface hardness, low
friction coefficient and anti-corrosion properties. The coatings also have the advantage of being thin, typically 1-4 μm. This feature, in conjunction with close tolerancing, means that the component retains its form, fit and dimensions after coating without the need for re-machining.

Introduced into the medical device industry nearly 20 years ago, PVD coatings like titanium nitride (TiN) are extremely hard (2,200 to 2,400 Vickers) coatings that provide excellent wear resistance. However, despite its functional properties, the first medical instruments used the coating as a decorative, high-end finish.

“Initially, the industry was looking for ways to differentiate instruments aesthetically and for identification purposes, and titanium nitride was a solution for that. To this day, it is the highest volume PVD coating used in the medical device industry,” explains Matt Thompson, business development manager in North America with Oerlikon Balzers, a company that has been producing specialised PVD coatings for more than 70 years.

Thompson adds that the orthopedic industry was the first medical segment to realise the functional strengths of PVD coatings, as applied to surgical instruments supplied with implants. The surgical instruments coated included items such as reamers, drills, taps and broaches.

Given its widespread use, titanium nitride is well established in the medical device industry. This is supported by a vast quantity of literature and testing that supports the bio-compatibility of the coating, and many precedents with the FDA.

As a result, other PVD coatings such as diamond-like-carbon (DLC) and aluminum titanium nitride (AlTiN) have gained widespread acceptance – particularly for coating stainless steel. This is significant because there are few surface treatments that can be applied to stainless steel while still providing the desired functional properties.

“DLC coatings provide an ideal combination of low coefficient of friction like PTFE, but with the hardness of a ceramic,” explains Thompson. “The coating has good functional properties, including excellent wear resistance, lubricity, corrosion resistance, anti-sticking and anti-fouling.”

The DLC Coating even improves sharp edge retention of surgical instruments, extending the service life of the instrument considerably. As an added benefit, cleaner cuts help surgical incisions heal more quickly, reducing patient recovery time.

In addition to its low coefficient of friction and wear resistance, PVD coatings may eliminate the need for lubrication, functioning even under dry running conditions. This is particularly useful for the pneumatic components of powered instruments such as surgical bone saws, or for the implantation and removal of intramedullary nails.

Surgeons that must perform under the harsh glare of operating room lighting have also found PVD coatings useful for its anti-glare properties.

Another important factor that device manufacturers must consider is whether the coating solution they choose contains antimicrobial properties. Invasive surgical instruments circumvent the body’s natural lines of defense. It is therefore critical that instruments’ surfaces are antimicrobial whenever possible to reduce the incidence of infection.

Oerlikon Balzers’ titanium nitride (TiN-Ag) coatings, which are doped with silver and have a film thickness of approximately 2 μm, were specifically designed to address this issue and are one of the only types of coatings on today’s market to offer this antimicrobial protection.

“Silver-doped titanium nitride is especially useful in trauma applications in which you’ve got a lot of open wounds,” explains Thompson. “These may require medium- to short-term implantation of devices and, subsequently, are prone to a higher percentage of surgical site infections.”

Using the bacterial log reduction test method, TiN-Ag has demonstrated high-antimicrobial efficiency with a Log 3 reduction with SA (staphylococcus aureus) and MRSA strain (methicillin-resistant staphylococcus aureus). Antimicrobial activity has also been confirmed by ASTM / JIS.

Nevertheless, regardless of a coating’s antimicrobial and bio-compatibility properties, it is, ultimately, worthless if it delaminates from the surface of a part after going through the thermal cycling of an autoclave cycle.

With that in mind, the TiN-Ag coating was designed to withstand multiple autoclave cycles without influencing the antimicrobial activity itself (demonstrating a Log 3 reduction after 50 autoclave cycles).

“An antimicrobial PVD coating has the potential to take a product to an entirely different level compared to the competition,” says Thompson.
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3D printing is the most well-known of all AM methods, and it has taken off in recent years. The fact that it has given engineers the luxury of rapid prototyping is a testament to its revolutionary nature, enabling them to perfect their designs in every aspect prior to mass production.

However, regardless of the capabilities of this design process, engineers are still faced with the challenge of making it environmentally sustainable and cost-effective so that it can be adopted on a much wider scale.

“One of the most common misconceptions regarding modern 3D printing is that only plastics are used in this process — but that’s simply not the case,” says Melissa Albeck, CEO of online materials database Matmatch. “Of course, resins are a popular choice as they offer a range of desirable properties like toughness or elasticity in solid form. SLA (stereolithography) and DLP (digital light processing) printers are common machines that are used to develop prototypes with resins.”

Printable materials
Modern design engineers, though, Albeck continues, have a wide array of different printable materials at their disposal whose applications differ depending upon numerous factors such as the material properties required, cost, colour, appearance, and layer thickness.

Metal is a popular alternative material choice as metals can be directly printed using various techniques like powder sintering or direct melting. Metals like aluminium, titanium, and stainless steel are popular choices among engineers due to their strength and metallic finish.

Glass has recently been used in AM to build complex-shaped items that are crucial to fields like optics and microfluidics, and ceramics are also a popular choice due to their shiny, glazed surfaces. Advanced (or technical) ceramics are used in the automotive industry, for small parts like filters or support mounts for catalysts for example, as well as in the biomedical industry.

Similarly, several organic materials are now also being used to develop materials for AM. They provide adequate quality and can offer environmental benefits. An interesting example of this is stone; powdered stone is combined with environmental-friendly thermoplastic polymer PLA (polylactide) which gives products both a natural look and texture as well as a strong structure.

“As these examples show, it is quite safe to say that plastics are not the only materials that AM techniques utilise” says Albeck. “What remains, though, is the question of sustainable materials that guarantee not only innovation in engineering, but also a greener, more liveable planet in times to come.”

The uptake of 3D printing is expected
to grow rapidly in the near future. A report by MarketsandMarkets estimates a huge compound annual growth rate (CAGR) of 21.6% in the five-year time period ending in 2021.

**Sustainable materials**

“With this growth rate, engineers need to develop environmentally sustainable AM materials quickly, and they have responded,” says Albeck. “Now some materials can be entirely dissolved in a solvent without any harmful emissions, like this 3D printed medicine.”

The medicine to which Albeck refers is called Spiritam, from US-based pharmaceuticals company Apricia, and uses ‘ZipDose’ technology. This is a drug-formulation platform that uses 3D printing to create medicines by binding powdered medication with a water-based fluid, resulting in solid yet porous medications that rapidly disintegrate when taken with a sip of liquid.

Researchers are even developing materials for AM that are water-soluble, such as Poly(ether ester) Ionomers polymers, which means no special solvent is required and there are minimal material losses in the whole manufacturing process.

“There is countless research being conducted with the sole purpose of obtaining printable materials derived from nothing else but natural products,” Albeck says. “Some of these natural products include very common origins such as algae (from seaweed) and corn starch – things that grow nearly everywhere.

“With materials being made out of natural products, there are massive environmental benefits. All of them are biodegradable and become a part of the natural environment once disposed of.”

For example, bioplastics producer Saphium Biotechnology has developed PHA (polyhydroxyalkanoates)-based filaments that are non-toxic and biodegradable. Applications of the material include waste-less prototyping and garden accessories. But in the future this kind of material could have wider applications.

Furthermore, there is a direct financial advantage in using such materials. Since most of them can be produced locally, without much expertise, there is no need to expend resources in transportation and synthesis.

Swedish company Cellink specialises in the production of such AM printers and bio-ink; the ‘ink’ is made from cellulose sourced from forests and alginate. It can be mixed with human cells and, in the future, the technology may facilitate the creation of functioning organs – potentially helping to address the shortfall in organs available for transplants.

Looking to the future, such research is likely to produce results that get more attention from engineers concerned with the well-being of the environment.

Albeck concludes: “There’s no guarantee as to how 3D printing will evolve, one thing’s certain; the use of organic and compostable materials will likely feature heavily as engineers continue working to protect our planet, while AM technology continues to advance at groundbreaking pace.”
Once again, Engineering Materials Live has offered a superb venue for materials suppliers and end users to meet and exchange ideas.

Following a highly successful event at the National Motorcycle Museum in May, Engineering Materials Live returned to the Imperial War Museum, Duxford in Cambridgeshire in September.

As always, Engineering Materials Live provided a venue where design engineers, manufacturers and production professionals could have face-to-face discussions and do business with plastic mouldings, composites, prototyped parts and advanced materials suppliers.

Engineering Materials Live is a specialist OEM engineering event delivering a focused showcase of engineering materials and related products and services. Visitors to Engineering Materials Live are typically design engineers drawn from the readers of leading journals, Eureka! and Engineering Materials. The event uses a refreshingly simple and well-proven road show style template that restores some traditional value for exhibitors.

Exhibiting companies included: plastics, rubbers, metals, composites, ceramics, alloys, lightweighting solutions, injection moulding, rapid prototyping, additive manufacturing, metal fabricators, design software (simulation, FEA, CFD), materials testing, design consultancy, minerals and natural fibres, sustainable materials, glass, carbon fibre, expanded materials, foams, coatings & finishing, conductive materials, surface treatment.

As ever, a key component of the event was the seminar programme. This time around, the first presentation came from Dr Heiko Wildner, chief operating officer of MatMatch, and concerned the inspiration for future material selection and sourcing and the way in which digitisation has the potential to change the way people discover and use materials.

Research from the Matmatch founding team showed that people currently tend to either stick to materials they already know or trawl Google for answers. So what role can digitisation play in changing this behaviour? How can we encourage people to broaden their horizons and consider alternative materials? In this talk, Dr Wildner presented a vision for the future of evaluating and sourcing of materials.

Next came Nigel Barrow, technical customer service manager, EMS-Grivory to discuss Grivory HT, which offers enhanced performance at high temperatures.

Grivory is the trade name for a group of technical thermoplastics manufactured and distributed by EMS-Grivory. The materials in this group are based on semi-crystalline polyamides with some partially aromatic content.
Grivory HT is a semi-crystalline thermoplastic construction material based on polyphthalamide (PPA) and is characterised by its high-performance properties. Technical injection-moulded parts made from Grivory HT retain their shape even at high operating temperatures. Thanks to its properties, Grivory HT is undoubtedly a high-performance plastic. In terms of characteristics such as stiffness and strength, among the most important in metal replacement, Grivory HT outperforms materials such as PPS or PEEK at operating temperatures up to 120°C. This presentation offered a chance to learn about the ‘New Generation’ of Grivory HT – High Heat & Hydrolysis resistance developed for the most demanding applications for Automotive and I&C.

The vexed issue of plastics and sustainability was addressed by Dan Jarvis of Plastribution.

With increasing levels of environmental awareness, driven in the main by the ubiquitous use of plastics, there is growing pressure on the plastics industry to respond positively on the long term importance of sustainable polymers development.

In providing solutions for the future, evaluating the environmental credentials of a ‘sustainable’ material or product is often complicated and sometimes difficult to judge.

This presentation sought to bring clarity to the issues and terminology used and whilst will not provide answers, it will provide relevant information to allow those attending to make informed and balanced decisions in the area of sustainability.

James Short, application engineer for Stratasys, discussed lightweighting and metal replacement through the 3D printing of carbon fibre and engineering thermoplastics.
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For any bricks and mortar businesses, one of the most significant investments they can make will be in plant and machinery. The natural temptation is often to keep the extent of this investment as low as possible while getting the job done in the most efficient and safest way possible.

However, that instinct may be leading businesses to miss out on immediate tax relief opportunities, long-term efficiency gains and reduced running costs. The Government has some long-standing commitments to reduce the nation’s carbon output and reduce waste in energy use, and part of its armoury here comes in the form of tax relief.

One of the most attractive is the Enhanced Capital Allowance (ECA) legislation that was introduced back in 2001 by then Chancellor, Gordon Brown. The scheme allows businesses to write off the entire cost of any product included on the Energy Technology List (ETL) against taxable profits.

The Government understands that the energy saving and efficient technologies that it would like the country’s businesses to invest in are, on the whole, much more expensive than the standard equivalent. So, in order to encourage take-up, the Government allows businesses to secure 100% first year tax relief on qualifying equipment.

To take advantage of this, the two main categories businesses should be looking at are energy saving and water conservation plant and machinery. This can be anything from electrical systems and lifts and escalators to cold water systems or heating and cooling systems. The stipulation is that the machinery or technology must be included on the ETL but the qualifying equipment on this list changes so it is important to ensure the latest information is being used before any investment is made.

To take advantage of this, the two main categories businesses should be looking at are energy saving and water conservation plant and machinery.

For example, if a business spends £10,000 on assets qualifying for ECAs, they would be able to secure tax relief of £2,100 in year one (where corporation tax is 21%). But spending slightly less (£9,000) on non-qualifying assets would deliver tax relief of only £340 in year one.

The benefits are clear. In fact, it’s pretty much a no brainer. But the returns on qualifying equipment don’t stop there – installation of the right equipment will lower a business’ overheads and reduce energy bills over the long term.

If businesses are looking to change or renovate existing premises, it’s worth speaking to their accountant about the ECA scheme. There are of course certain requirements that must be satisfied to qualify for the tax relief but with the right advice, any business can not only make their premises more energy efficient, they can enhance their green credentials in a meaningful way, boost cashflow and keep investment in costly plant and machinery to a minimum.

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To take advantage of this, the two main categories businesses should be looking at are energy saving and water conservation plant and machinery.

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FOR THE BIRDS

Arable farmers are constantly looking for new ways to scare birds from their valuable crops.

An Argentinian winery recently conducted a trial and found that, in three months, more than £25,000 of damage was done by birds in just one field. Obviously, this level of damage is far above that which could potentially be dealt to a British farmer growing broccoli or cauliflower, but the bottom line is the bottom line.

Historically, scarecrows and more recently gas cannons have been used to keep flocks of marauding wood pigeons, collared doves, jays, blackbirds and finches away. The problem with this is that certain birds are clever and become used to these deterrents if no variation is introduced.

The most obvious and effective way to introduce variation is for someone to physically go into the field and shoot to scare. But this takes them away from another job, reducing the farm’s productivity.

THE CHALLENGE

This month’s challenge is to come up with a technological way to keep ravenous flocks of birds off farmers’ crops, as a solution to the problems they pose “remains elusive”, according to the British Trust for Ornithology (BTO). Most importantly, your solution needs to be humane, must not contain any harmful chemicals but must be inconsistent with its scares to keep those pesky birds on their toes.

The idea we have in mind will be revealed in the December issue of Eureka! Until then see what you can come up with. Submit your ideas by leaving a comment on the Coffee Time Challenge section of the Eureka! website or by emailing the editor: paul.fanning@markallengroup.com

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