THE ENGINEER

Collaborate to Innovate

NOVEMBER 2019

A CELEBRATION OF THE UK'S MOST INNOVATIVE ENGINEERING COLLABORATIONS

In association with

FRAZER-NASH CONSULTANCY

JON EXCELL

Welcome to a celebration of collaboration

Modern engineering spans a dizzying and sometimes surprising range of application areas. But as this special issue of The Engineer demonstrates, the most successful engineering projects often have one common ingredient: they're the product of collaboration – the meeting of different mindsets, ideas and disciplines that so often provides the spark for innovation.

Now in its fourth year, The Engineer's Collaborate to Innovate awards was launched to celebrate this dynamic and uncover some of the UK's most innovative and inspiring examples of engineering collaboration in action.

Over the following pages we spotlight the winners of this process, and examine how collaboration has been key to their success.

As well as demonstrating how engineers are applying emerging technologies to solve some of mankind's most pressing challenges, this year's finalists can also teach us some valuable lessons: not least the huge benefits of embracing a cross-disciplinary approach, and how ensuring that every member of a team is aware of the end goal is the most effective route to overcoming some of the challenges collaborative working presents. Many of our winning projects also highlight a particular strength for the UK, the richness and depth of its academic/industry collaboration and the incredible things that can be achieved when academia and industry are truly aligned.

As the stories over the following pages demonstrate, there are plenty of reasons to be positive about the state of UK innovation. But the conditions that sustain it shouldn't be taken for granted and it's important that industry academia and government work together to nurture and maintain this climate.

One key to this is ensuring that we have the skills base to continue to innovate in the future by inspiring and engaging the next generation of engineers, something that we celebrate in this year's Young Innovator award.

Finally, I'd like to take this opportunity to say a huge thankyou to all of the judges, sponsors, supporters and engineers who have helped to make Collaborate To Innovate 2019 such a rewarding and fascinating initiative.

Jon Excell

EDITOR • JONEXCELL@MARKALLENGROUP.COM

CONTENTS

THE ENGINEER

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

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

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

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

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

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

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

Production Andrew Ganassin
andrew.ganassin@markallengroup.com

Publishing director Luke Webster
01722 714847
luke.webster@markallengroup.com
Subscriptions & Customer Services
circulation@markallengroup.com
The Engineer is available for International licensing and syndication. For more information please email
luke.webster@markallengroup.com
News 020 8076 0576
Display 020 8076 0582
Recruitment 020 8076 0581

UK subscriptions £75 pa UK/£117 pa overseas. Order online at www.theengineer.co.uk/subscribe. Visit www.theengineer.co.uk for constantly updated news, products and jobs and to sign up for our FREE weekly email newsletter and tailored job alerts

MARK ALLEN GROUP

www.markallengroup.com

MEET THE JUDGES

This year's shortlist was evaluated by leading figures from across the UK engineering and technology sectors

ABBIE HUTTY

STM and GTM Delivery Manager and Structure Supplier Operations Manager, ExoMars Rover Project at Airbus

"I think it's brilliant to see the breadth and scope of engineering collaboration in this country and how we're bringing innovation to tackle the grand challenges of our time"

ROSA WILKINSON

Director of Communications, High Value Manufacturing Catapult

"The C2I awards recognises the need to bring people together from different tranches. Reading some of the entries this year has been inspirational."

NEIL MCDOUGALL

Managing Director, Frazer-Nash Consultancy

"The thing that's really encouraged me is the breadth of entrants, the strength of entries into the competition and also the strength of winners. They are the best of the best. "

PHILIPPA OLDHAM

Head of National Network Programmes, Advanced Propulsion Centre

"What we've seen from the awards is not only some game changing technologies that can have a real impact now but the opportunity for future innovation and those products comithrough that can help the growth of the UK economy."

DR KEDAR PANDYA

Associate Director, Business Engagement and Industrial Strategy EPSRC

"In the vast majority of cases you see the real excellence of the academic endeavor in this country being both a magnet for industrial collaboration but also a multiplier for the kinds of impacts we can have out into the economy."

JOHN HALTON

Director, Business & Industry, Engineering UK

"This has been the third year I've judged this competition and again there's been a great submission of projects. The collaboration element is going to become even more important from both and academic and business perspective"

ALAN NEWBY

Director Aerospace Technology and Future Programmes, Rolls-Royce Plc

"I was impressed by the breadth and depth of the entries, in particular numerous examples of people coming together and collaborating to solve some of society's biggest challenges. "

PROFESSOR ANDY WRIGHT

Director Strategic Technology, BAE Systems Programmes and Support

"I'm always amazed at the strength of what's produced and submitted: the strength in terms of engineering and scientific prowess and the ability to be able to take ideas from incubation through to something tangible that impacts our society. "

STEVE PENVER

Head of Data & Analytics, Babcock International

"I'm taken aback by the strength of the entries and I think it just goes to show how important collaboration is to driving innovation"

FRAZER-NASH CONSULTANCY

Keeping the ideas pipeline flowing

Mentoring and inspiring tommorrow's engineers is key if we're going to sustain and grow a culture of innovation and collaboration

WRITTEN BY NEIL MCDOUGALL, MANAGING DIRECTOR, FRAZER-NASH CONSULTANCY

As we celebrate all of the innovations entered into 2019's Collaborate to Innovate (C2I) awards – and perhaps even start to think of the novel solutions in our development pipelines for entry in 2020 – we should, I believe, be looking beyond the next few years, and into the more distant future. This century will bring advances in technology, equipment and systems that we can't yet imagine but, for the present, our profession is being held back by a lack of entrants wanting to join its ranks. How are the young innovators, who have taken part in the great programmes entered into C2I this year, going to ensure that the well of innovation doesn't run dry?

The skills shortage in engineering is, of course, well-recognised: the government has predicted a shortfall of around 186,000 engineers each year until 2024. But, even by 2024, the range of expertise needed by many engineers will have changed. Data and digital technologies are revolutionising today's healthcare; advanced materials are delivering increases in sensors' efficiency, enabling us to gather useful information; and intelligent systems are transforming our travels. Our future innovators will need to develop a good understanding of 'new' skills such as coding, modelling, simulation, and systems architecture as we move towards this 'digitopia'.

So we need to fill this skills gap, both for now and for our future. As an industry, we need to be working together to ensure that today's students appreciate how interesting, challenging and exciting a career in engineering can be. We must address people's misconceptions about the industry – whether these beliefs are about the gender, ethnicity, sexuality or socio-economic background of who becomes an engineer – and, as the Institution of Engineering and Technology (IET) suggests, 'smash stereotypes to bits'. But, in encouraging tomorrow's engineers, we mustn't forget today's – we need to upskill our existing people with lifelong learning, to ensure they are fully engaged with new technological advances.

> " TODAY'S ENGINEERS MUST WORK WITH THOSE ENTERING THE PROFESSION - OR WITH THE POTENTIAL TO ENTER IT - TO MENTOR THEM AND PASS OM THEIR EXPERIENCE

Engineers have always focused on providing solutions to global problems – from delivering affordable energy and clean water, to empowering communication across vast distances, to ensuring structures are safe. But tomorrow's engineers will have to ensure that the answers they are offering to society's big questions are also sustainable and ethical. This goes beyond solely the technical aspects – in an increasingly automated world, engineers must make sure their new systems have the human user at their heart.

I have every faith that tomorrow's engineers will be up to the challenge. Just as today's engineers and C2I show, they will be creative, questioning and curious about the world and the things in it, and want to use their critical thinking and ingenuity to solve problems. They'll be able to manage projects, plan, budget and negotiate; have incredible communication skills and be fantastic members of successful teams. And, just like today, they'll use their commercial thinking skills to create new business and delivery models.

As we've seen from C2I, collaboration is a crucial element of innovation. Today's engineers must work with those entering the profession – or with the potential to enter it – to mentor them and pass on their experience. But mentoring is a two-way process, and we have just as much to learn from tomorrow's engineers as they have from us, to ensure that our pipeline of ideas keeps flowing.

WINNER
AEROSPACE, DEFENCE & SECURITY

SPONSORED BY

CATAPULT
High Value Manufacturing

Lightbulb moment for space travel

Electricity generated from rare element could help power missions to the distant solar system for 400 years

Britain has a unique problem – the world's largest stockpile of civil plutonium. Built up over seven decades, almost 140 tonnes of the radioactive metal sit in secure storage at Sellafield, and are officially classified as nuclear waste. However, it is potentially a fuel for the nation's nuclear power stations, but not in its current form. The question of what to do with the UK's plutonium has dogged successive governments. The winner's trophy for this year's aerospace category has gone to Richard Ambrosi from the University of Leicester, who led a collaboration with the UK National Nuclear Laboratory (NNL) to extract a fuel from the stockpiled plutonium that could power humanity's exploration of the distant solar system.

Most space probes are powered by photovoltaic cells, but solar power is not suitable for all exploration missions. Deep into the solar system, the distance from the sun is so great that its rays are too feeble to provide enough power. Conversely, too close to the sun and the elaborate cooling systems needed to keep the spacecraft functional require more power than solar panels can provide. On planets and moons with thick cloud cover, the sun cannot penetrate to the surface.

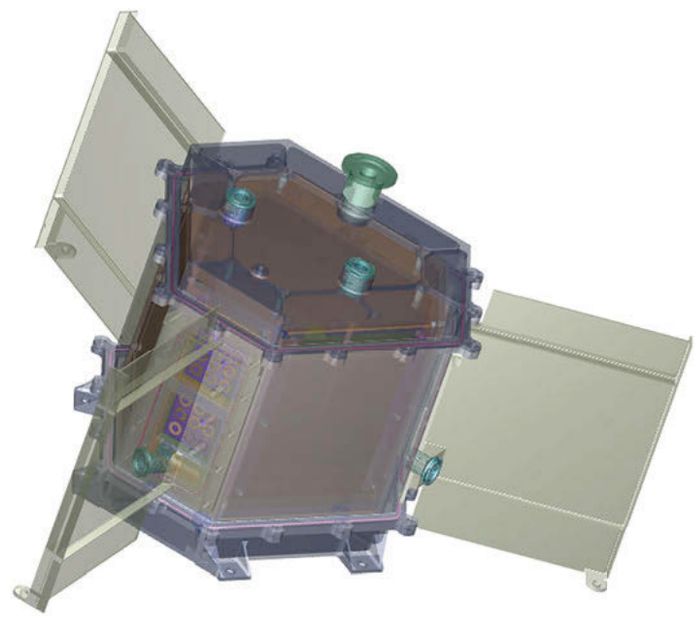
In these cases, engineers use nuclear power. This is in the form of a device called a radioisotope thermoelectric generator (RTG), consisting of a chunk of a radioactive material which gets hot as a result of nuclear decomposition. One end of a thermocouple is attached to the hot material, while the other is kept at the much colder temperature of the spacecraft's environment. The temperature difference forces a current to flow from hot to cold.

RTGs are extremely reliable: they have been powering the US Voyager probes for decades, and NASA's Curiosity rover contains one that allows the vehicle to operate during the Martian night. They generally use plutonium 238 (238Pu) in the hot component. But this isotope is in short supply, and is only produced in specialist nuclear reactors. The European Space Agency (ESA), which currently does not operate any RTG-powered spacecraft, decided in 2009 that it would develop its own capability so that it could consider deep space exploration missions, and as part of this effort, NNL contacted Ambrosi's team at Leicester, who are specialists in RTG technology.

Ambrosi explained to *The Engineer* that the plutonium stockpile, a result of reprocessing nuclear fuel, was an obvious choice of source for an RTG fuel. "The plutonium isotope it contains is not in itself suitable, but as it is stored its natural decomposition contaminates it with americium 241 (241 Am). If you want to then utilise the plutonium in a nuclear power plant, you have to extract the americium anyway to clean up the plutonium."

"There was a sort of a marriage brought about by the ESA funded programme," Ambrosi continued "Our focus is mainly at Leicester on how you take heat and convert it to electrical power. And now we're focusing on the development of the actual source of heat. It made very good sense for us to work collaboratively because we were both involved in the common ESA program goal of developing a new power generation technology for space applications. The space project was an important catalyst in driving the development of the chemical separation process that allows you to then extract the americium from the plutonium."

"It's a relatively simple chemical process," explained Ambrosi's colleague Chris Bicknell. "The plutonium is dissolved, and the National Nuclear Lab have developed a proprietary process which allows you to precipitate out the americium from that solution. And then you can harvest that americium and effectively what emerges from that is a ceramic powder, which you can then turn into a pellet." This consolidated ceramic pellet becomes the hot side of the RTG in a spacecraft.



PROJECT NAME

UK Scientists generate electricity from rare element to power future space missions

PARTNER

University of Leicester, National Nuclear Laboratory & European Thermodynamics Ltd

241 Am is suitable for use in RTGs, but it is not a direct replacement for 238Pu. Although it has a half-life of over 400 years, its power density is only a quarter that of 238Pu and it requires more shielding.

The Leicester team developed a thermoelectric conversion technology specifically for this project, with a special geometry for the thermoelectric modules designed to maximise the temperature difference between the 241Am pellet and the exterior environment. The element that converted temperature difference into electric current was a semiconductor based on bismuth telluride, and earlier this year the team demonstrated that this could produce enough current to operate an electric light. The Leicester team developed a novel spark-plasma sintering technology to synthesise the bismuth telluride, and attached a capacitor-based electricity storage system to the generator which acted as a power source for the light.

Your High Value Manufacturing Catapult.
The go-to place for advanced manufacturing technologies in the UK

CATAPULT
High Value Manufacturing

Working with
Innovate UK

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

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

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

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

Proud sponsor of the

Aerospace, Defence & Security

Award Category

Find out more:

hvm.catapult.org.uk

+44 (0)1564 711 540

info@hvm.catapult.org.uk

@HVM_Catapult

WINNER
AUTOMOTIVE

SPONSORED BY
COMSOL

Gaining traction

UK developed magnet free electric motor ready for the road

A new, magnet-free electric motor design promises to combine the performance of existing traction motors with greater sustainability.

The culmination of six years of research, the High Density Switched Reluctance Motor (HDSRM) has recently gone into production and will be powering commercial vehicles on the road within months.

The project is led by Advanced Electric Machines, a spin-out company from Newcastle University, in collaboration with commercial vehicle maker Tevva Motors, the university itself, and software specialist Motor Design.

Among the motor's main attributes is the elimination of rare earth permanent magnets and copper, both of which make end of life disposal more difficult.

The motor is expected to be used in a wide range of applications, but initial development has focused on the commercial vehicle market.

Commercial vehicles often operate at the peak of their performance range for hours at a time, covering a large number of motorway miles. A robust technology which can operate at peak efficiency for long durations is therefore needed. The commercial vehicle sector is also heavily focused on total cost of ownership. AEM believes that successful electric vehicle technologies will be those that provide cost savings as well as environmental benefits. This means taking into account efficiency in operation, the cost of servicing and disposal costs.

Up to now, electric vehicles have used permanent magnet motors. Advanced Electric Machines chief executive Dr James Widmer said: "It struck us that the automotive industry was heading down the road of building future electric vehicles using materials with associated problems in the short, medium and long term." These include rare earth elements used in permanent magnets, as well as copper for the motor windings.

PROJECT NAME

Magnet Free Traction Motors for Commercial Vehicles: HDSRM

PARTNER

Advanced Electric Machines Limited with Tevva Motors, Newcastle University, Motor Design Limited

Switched reluctance motors have existed almost as long as the internal combustion engine, but have suffered from weaknesses in performance which have limited their use in electric vehicles.

Unlike common DC motor types, in a switched reluctance motor power is delivered to windings in the stator rather than the rotor. This simplifies mechanical design because power does not have to be delivered to a moving part.

The rotor is made of a "soft" magnetic material such as laminated steel, with projecting magnetic poles. The stator also has a number of poles. When power is applied to the stator windings, the rotor moves to align the rotor pole with the nearest stator pole. To keep the rotor moving, an electronic control system switches on the windings of successive stator poles ahead of the rotor, so it continues to rotate.

However, switched reluctance motors gained a reputation for being noisy. They also suffered from torque ripple – fluctuations in torque as the rotor rotates – which made them unsuitable for traction applications. They required different power electronics from permanent magnet machines to drive them, which, without economies of scale, were expensive.

AEM's breakthrough has been to make it possible to drive the SR motor using the same power electronics as a permanent magnet motor. And although it appears to the power electronics as a standard three-phase motor, it is in fact a six-phase design, which solves the torque ripple and noise problems.

The switched reluctance motor is more sustainable in three ways, said Dr Widmer.

First, environmentally, the mining and refinement of rare earth elements pose significant problems if not properly managed, and also produce large quantities of carbon dioxide. Second, China controls more than 90% of the world's supply of rare earth minerals. Third, rare earth elements are expensive – typically $100/kg (a motor for a vehicle such as the Nissan Leaf needs around 2kg), and prices are volatile, particularly given the current US-China trade war.

AEM has also developed a patented manufacturing process that allows aluminium to be used for the windings. Aluminium is a tenth of the price of copper and easier to recycle – because it melts at a lower temperature than steel it can be recovered separately at the end of a motor's life, whereas copper contaminates the steel.

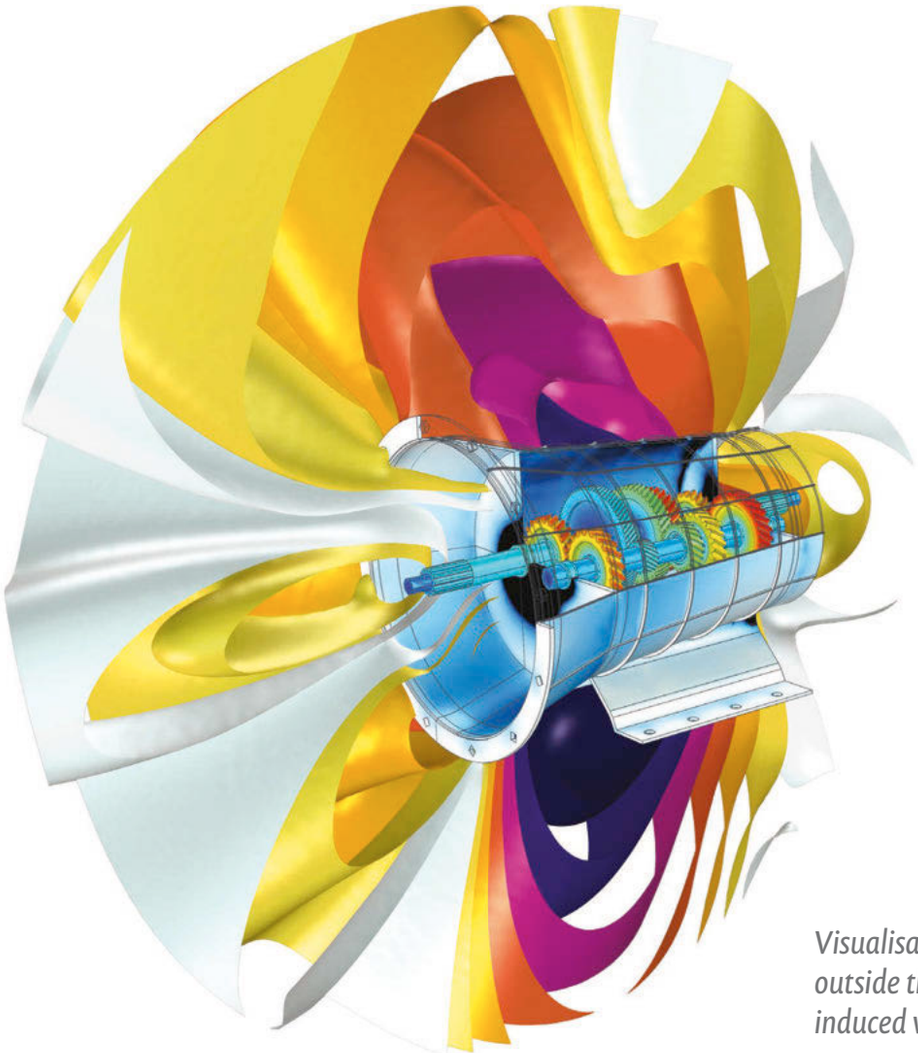
Another drawback of permanent magnets in conventional motors is that they become demagnetised if they get too hot. In a hybrid vehicle the electric motor needs a separate cooling loop from the internal combustion engine. A switched reluctance motor can be run hotter, and can be cooled by the IC engine cooling system.

A further difference is that permanent magnet motors are never "off". The motor will always generate either current or torque while rotating. When the HDSRM is not being driven it is truly "off", and the AEM team has patented a multi-motor design which allows one or more motors to be turned on or off to match vehicle's a performance requirements at any given time.

The multi-motor system can thus be operated at peak efficiency over a much broader part of the vehicle drive cycle.

AEM has production capacity of 12,000 units annually and its motors are being evaluated in other areas, such as marine ancillary power and in industry, where they can replace induction motors, working with standard industrial drives. "Anything that can spin a permanent magnet motor will drive our motor," said Dr Widmer.

Design quieter gearboxes with multiphysics simulation.



Visualisation of the noise pressure level outside the gearbox and vibration-induced von Mises stress in its housing.

Noise, vibration, and harshness (NVH) testing is an important part of the design process, but you are not limited to conducting physical experiments. When optimising gearbox designs, you can perform vibroacoustic analyses using simulation software — producing virtual test results you can see and hear.

The COMSOL Multiphysics® software is used for simulating designs, devices and processes in all fields of engineering, manufacturing and scientific research. See how you can apply it to modelling gearbox vibration and noise.

comsol.blog/NVH-simulation

COMSOL

WINNER
ENERGY &
ENVIRONMENT

SPONSORED BY

GoodFellow

Smart local energy systems at Trent Basin

Nottingham engineers pioneer community energy network technology

Fancy living in a new riverside development close to a city, where residents share a community energy network and you might reduce your energy bills by 25%? Well now you can. Trent Basin, a housing development in Nottingham, is the UK's first working sustainable community energy network, and the outcome of some smart sustainable engineering.

Project SCENe is a working partnership between engineers at the University of Nottingham, the local authority and experts from the housing and energy sectors that's transforming local energy infrastructure and could be rolled out across the UK.

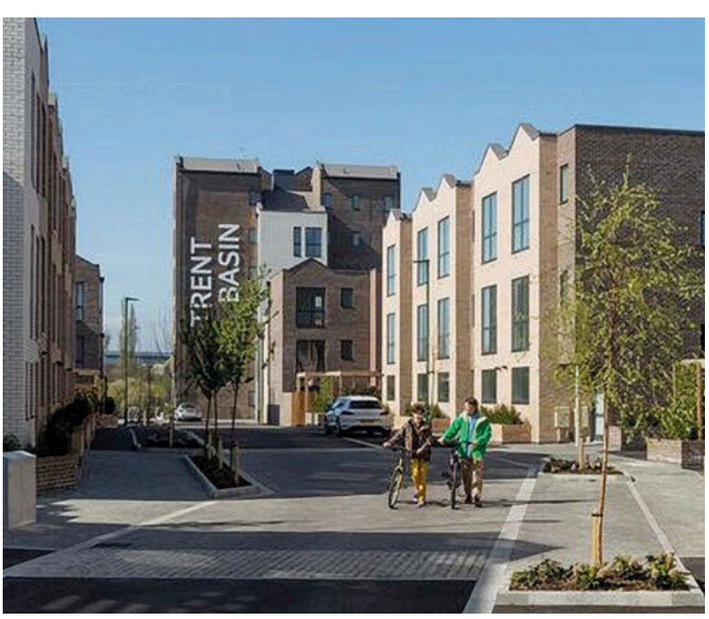
The project applies multi-vector energy systems, including solar power and localised energy storage, combined with carbon neutral housing technology, to create what the partners say is the first robust and "smart" business model for sustainable community energy.

A team led by Professor Mark Gillott, Chair in Sustainable Building Design at the university and the academic lead for project SCENe, built an early demonstrator living lab at the university campus, using smart technology to monitor and record energy shared usage, which gave commercial partners the reassurance to scale it up.

The model was transferred into Trent Basin where 42 homes are already inhabited and plugged in to the system, another 31 sustainable homes are being built and 500 homes are planned. Trent Basin is the first ever new-build residential site to generate, store and use this electrical power for community benefit.

PROJECT NAME
SCENe (Sustainable Community Energy Networks)

PARTNER
University of Nottingham with Loughborough University, Igloo Blueprint, Urbed, Siemens, Solar Ready and Confers



Since May 2018 when the system went online, SCENe has saved 110 tonnes of CO2, generated over 310,000 kW/hours of renewable energy, offset energy costs by 25% and created a new company and business model that is attracting interest from more developers.

House buyers are invited to join the community energy company, with shared profits helping offset energy costs. Data generated by free energy monitoring kits will influence the roll-out of schemes across the UK.

SCENe generates its own renewable energy from solar panels fitted on the homes. These feed a community battery – claimed to be the largest in Europe - supplied by Tesla, that stores power locally and is connected to the national grid

Then smart monitoring systems capture lots of data using equipment provided by the technologist partners. In-home energy monitoring kits tell residents how much energy they're using, whilst interactive apps showing each home's and the network's energy usage can be accessed via smart devices. Voice-activated Amazon Echo Spots give more information to residents, on demand, to make better choices about energy consumption.

The battery can store 2.1MWh of energy that delivers 500kW of power, enough to power 167 electric kettles simultaneously for over four hours.

"We make decisions about the energy's deployment," said Gillott. "Could we get better value from trading with the grid, at this time? Or could it be best used for vehicle charging, heat generation or local use? It's about optimising the use of local [

energy assets while integrating with the national grid to get best value from them."

The consortium of partners delivering the scheme includes developers Igloo Blueprint, AT Kearney, spin-out company Trent Basin ESCO ltd, Smartklub, Siemens, URBED, Slam Jam, Sticky World, Solar Ready, plus Loughborough University and with support from Nottingham City Council.

"For me the key to its success is the industry collaboration," said Gillott. "Its vitally important that we decarbonise the built environment. We need partnerships between industry and academia to deliver this is in the real world, to exploit our research and scale this up. The key thing for entering this award is that it could not have been realised without collaborations between the housing and energy industries, developers, technology suppliers, linked with ourselves to deliver this platform."

Trent Basin is also a unique business model, Gillott added. Here the energy system is developed with the developer but they are not taking the risk. From the early work on campus, SCENe has created an energy services entity, a special purpose vehicle called Trent Basin ESCO ltd, to trial and test the business model using the assets that are connected.

Trent Basin is now attracting national and international interest in the concept of Local Community Energy. One outcome to promote is that 83% of the Trent Basin residents would recommend the installation of energy storage equipment in their homes to other members of their community.

"We have already been approached by other developers wanting to collaborate on new projects," said Gillott, "it proves how to operate a smart local energy system with a business model that is viable and hassle-free for consumers to use."

WINNER
HEALTHCARE
& MEDICAL

SPONSORED BY

SOLIDWORKS

Cancer cell detecting probe promises to make surgery more effective

Advanced radiation detection device poised to undergo clinical trials

In cancer surgery one of the main difficulties for surgeons lies in distinguishing between cancerous and healthy tissue. The risk is twofold: cancer cells can be missed so the patient requires further treatment, or healthy tissue is unnecessarily removed, which can lead to other health consequences and complications.

Lightpoint Medical's Sensei probe aims to address this problem by making it possible to identify cancer cells during laparoscopic (keyhole) surgery in real time.

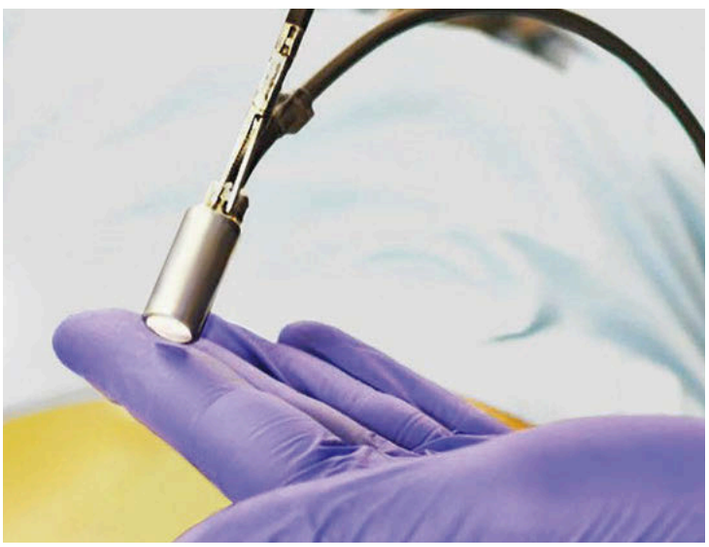
Lightpoint, in partnership with the National Physical Laboratory, is seeking to achieve this by using radiopharmaceuticals: radioactive drugs widely used in pre-operative diagnostic imaging of cancers. "The innovation is in developing novel detectors that can detect these drugs interoperatively, specifically for laparoscopic surgery, and give live feedback to the surgeon, so they can target the cancerous tissue while sparing healthy tissue," explained Dr Kunal Vyas, Lightpoint Medical head of research.

The device has almost completed its product development phase and Lightpoint's team is preparing for clinical trials, which are expected to start early next year.

The principle on which the probe operates is this: the patient is injected with a cancer-targeted imaging drug commonly used in SPECT imaging (single-photon emission computed tomography).

The drug is selectively absorbed by cancerous cells, which then emit a radioactive signal that can be detected by the probe, in order to guide the surgeon as to what areas to target. The probe emits an audio signal when it detects radioactivity and can be manipulated manually or robotically.

There are a number of areas of innovation, said Dr Vyas. "The biggest engineering demand is miniaturisation," he said: the probe must fit through a 12mm trocar (the keyhole or portal to the abdomen used in laparoscopic surgery).



PROJECT NAME

Laparoscopic molecular probe for prostate cancer surgery

TEAM

Lightpoint Medical with National Physical Laboratory

The second innovation is the tethered format. The probe is a small instrument on a flexible cable. A nodule behind the probe head allows it to be grasped by a manual or robotic surgical grasping tool operated by the surgeon from outside the patient's body. "This allows them to articulate our probe through the full six degrees of freedom," Dr Vyas said.

A third area of innovation is exploiting the use of radiopharmaceuticals as diagnostic agents and applying this to surgery and this is where NPL's expertise in radioactivity and handling radioactive materials came in.

NPL - which played a crucial role in demonstrating that the probe would work in the radiation environment in a patient's body - was able to supply radioactive isotopes at the required concentrations, and had established procedures and facilities for using and handling the materials safely, as well as the expertise in measuring radiation very precisely.

The organisations mapped out the critical abdominal organs and structures – and created a physiological "phantom" or physical representation of the abdomen.

A crucial aspect element was the pelvis. Because bone scatters and absorbs radiation, NPL devised a bone-mimicking material with the same density, scattering and absorption properties, and created a model of the pelvis using additive manufacturing.

The phantom also had representations of the organs which would have significant radioactivity in them – the prostate itself, the liver and the bladder – to which capsules containing a precise amount of radioactivity, based on the medical literature, could be added in a safe way.

Several surgical specialists used the model to evaluate different grip designs and to demonstrate that they could successfully manipulate the probe and detect the radioactive capsules.

The probe is now ready for clinical trials. The first application will be to detect sentinel lymph nodes for sentinel lymph node biopsy, in prostate cancer surgery.

In this procedure, lymph nodes nearest to the tumour are removed so they can be tested by a pathologist to give an indication of whether the cancer has spread or not.

Approval for this could be gained quite quickly, and is expected later in 2020. Dr Vyas explained that although the device is novel, sentinel lymph node biopsy uses a standard drug and is a well-established procedure.

A second trial will use a more advanced drug, aprostate specific membrane antigen, which specifically targets prostate cancer and will allow lymph nodes to which cancer has actually spread to be identified. "That will be the first time that radio-guided surgery will have been used for that purpose," said Dr Vyas.

"From the point of view of improving outcomes for the patient, the first trial will be significant because current practice is to remove all pelvic lymph nodes," said Dr Vyas. "This leads to severe side-effects, such as a high risk of infection." And unnecessarily removing healthy tissue carries the additional risk of accidental damage to critical nerves in the area.

"It's about removing as little healthy tissue as possible. If you can be more precise and more targeted you can achieve the same clinical benefits without the downsides," he added.

Dassault Systèmes SOLIDWORKS® is proud to be associated with the

Healthcare & Medical

AWARDS CATEGORY

The medical device manufacturing industry is growing at an incredible pace in order to keep up with increased demand. Medical device product designers must not only create innovative medical products but also navigate an increasingly challenging regulatory environment.

From virtual simulation and regulatory data management to flexible industrial design capabilities, SOLIDWORKS enables medical device companies to **design regulatory-compliant medical breakthroughs.**

DASSAULT SYSTEMES | The 3DEXPERIENCE® Company

WINNER
INFORMATION, DATA & CONNECTIVITY

Eyes in the sky help boost bridge safety

A combination of satellite technology and a bespoke sensor package is enhancing structural safety for bridges and buildings

When bridges fail it can result in huge loss of life, as the 2018 Ponte Morandi collapse so tragically demonstrated. That day in Genoa saw 43 people killed and 16 injured. While death tolls on this scale are mercifully rare, our C2I winner in the Information, Data & Connectivity category could help consign major bridge disasters to the pages of history.

GeoSHM (GNSS and Earth Observation for Structural Health Monitoring) uses multiple space technologies combined with in-situ sensors to provide a real-time picture of bridge movement and stresses. At the core of the system are GNSS (Global Navigation Satellite System) receivers that pick up positional data via the GPS, Galileo and BeiDou Navigation Satellite (BDS) constellations. This real-time monitoring is complemented by interferometric synthetic-aperture radar (InSAR) data provided by Earth Observation (EO) satellites that can track potential ground subsidence of the structure.

The technology is being brought to market by UbiPOS UK, a spinout from the University of Nottingham. Collaborating partners include Leica Geosystems, Geomatic Ventures Limited and China Railway Major Bridge Reconnaissance & Design Institute (BRDI). Various incarnations of the system have been deployed on the Forth Road Bridge (FRB) for over a decade, in partnership with Transport Scotland and current FRB operator, Amey.

"We started working with the Forth Bridge about 15 years ago," Professor Xiaolin Meng, director of Nottingham University's Sino-UK Geospatial Engineering Centre, told The Engineer.

"I think we have eight locations with more than 20 sensors on (the bridge). As you can imagine, we also have to have a communications link…initially we used optical fibres but in the end we found that optical fibres were not adequate, so we installed wireless communications on the bridge as well."

In November 2018, the consortium deployed its first all-in-one monitoring suite on the FRB, combining GNSS receivers with an accelerometer, antenna and communications module. The patent-pending kit sends real-time data back to users via the GeoSHM Analyst Toolbox, where AI and analytics help evaluate the overall structural health of the bridge.

Additional data on temperature, humidity, wind and traffic loading helps paint an even richer picture, with GNSS delivering positional accuracy of around 1cm in three dimensions. According to Professor Meng, the different individual sensor packages on the bridge not only utilise GNSS for position, but also rely on its timing signal to confirm that data from all nodes is synchronised. This ensures that fluctuations and flexes in the bridge's deck and pylons are mapped correctly in real-time and that engineers can see precisely how the structure is moving at any given point.

"All sensors are actually synchronised with GPS time, which has nanosecond accuracy," said Meng.

Away from the UK, collaboration partner BRDI in China has deployed a prototype system on two of its long-span rail bridges that cross the Yangtze river. China Railway operates more than 1,000 long bridges across the country, presenting a huge market opportunity for the technology. In 2020, GeoSHM will be installed on the Hutong Yangtze River Bridge, which will be the world's largest cable-stayed road-rail bridge, reaching 1,092 metres with its main span.

"By collaborating with BRDI and providing our expertise in earth observation and monitoring technologies, we can help to improve the way that bridges are constructed," said Meng. "The wide-reaching range of geospatial data that we are able to provide through our research work also has massive potential in helping to develop smart transport management solutions within the big cities in the UK and China."

As well as backing from Innovate UK, Amey and Transport Scotland, GeoSHM has also received financial support from the European Space Agency (ESA). Now that the technology has been proven on multiple bridges, there are plans to roll it out across other major infrastructure. A large dam in China is set to have GeoSHM sensors deployed, while the consortium expects the market for monitoring high-rise buildings to be one of its biggest growth areas.

PROJECT NAME
GeoSHM

PARTNER
University of Nottingham with UbiPOS, BRDI, Leica Geosystems, GVL & Transport Scotland

"In Dubai, we have an 800m high building, and how to safeguard these big assets is a challenge," said Meng. "So, we're trying very quickly to take this market on board."

According to the Professor, opportunities are also being explored in the US, where the team is working in collaboration with AECOM. Though the country's infrastructure presents a range of potential areas for expansion, Meng says the consortium is particularly interested in the dozens of bridges that serve New York City.

WINNER
MANUFACTURING
TECHNOLOGY

Thinking small, building big

UK led consortium scales up nano particle production

Radio frequency identification (RFiD) tags are a key underpinning technology for the so-called Internet of Things.

But the high cost of producing one of the key raw materials for these tags - silver nano-particles - is holding back the full potential of the technology.

University of Nottingham spin out Promethean Particles hopes to change this.

Promethean is the outcome of a consortium of 18 industry and academic partners across Europe that developed the SHYMAN project (Sustainable Hydrothermal Manufacturing of Nanomaterials) winning a €10 million EU Framework 7 grant to develop a cleaner process to manufacture nanomaterials in large volumes.

These tiny particles, that can measure less than one billionth of a metre, are used in the manufacture of inorganic and organic pigments and metal nanomaterials, which are used in industrial applications including printed electronics, Metal Organic Frameworks (MOF), catalysts, healthcare and nanocomposites, including plastics and coatings.

SHYMAN has led to Promethean building the largest multi-material nanoparticle plant in the world, in Nottingham. The process – a continuous, sustainable hydrothermal synthesis of high-quality inorganic nanoparticles – uses hot water rather than potentially hazardous chemicals to fabricate the nanoparticles.

Crucially, the process has been successfully scaled up, and the working plant is able to produce up to 200 kg of nanoparticles per hour. It now produces 1,000 tonnes of nanomaterials a year, making it viable for commercial supply to chemical and industrial companies including Solvay, Fiat and Repsol.

"The technology had come to light nearly 20 years ago but the synthetic chemistry community had written it off as impractical," said Professor Ed Lester, lead academic on SHYMAN and technical director at Promethean Particles

In 2016, SHYMAN won a European Commission grant worth €10 million, with €2m to build a plant with the capacity to make 100 tonnes a year. "But we scaled it 10 times bigger than we were awarded the money for. That was an interesting financial challenge," said Lester. "We wanted to derisk the technology completely because even with 100 tonnes you would still get naysayers that would doubt you'd be able to reach 1,000 tonnes volume."

Whilst most chemical plants are designed to make one specific product Promethean is capable of producing many variants of nanomaterial that can currently be developed at bench scale.

As well as pulling expertise from large chemicals firms like Solvay, universities from Ireland, Spain, the Czech Republic and Poland were involved. The full consortium also included materials developers (UniPress), modellers (Universidad del Valladolid), analytical specialists (PR associates), formulators (VLCI) and end-users, covering the total value chain.

Marie Ticha from the Czech Technical University, who worked on modelling the sustainability of the process, said "[Our university] was responsible for providing environmental impact assessment not just on the production technology, but also on selected applications of nanomaterials throughout their life cycles using Life Cycle Assessment (LCA) methodology. Our cooperation with the University of Nottingham and other European partners within the SHYMAN project significantly improved our experience in this field, which was positively reflected both in the work with students and in cooperation with Czech companies engaged in the production of nanomaterials."

PROJECT NAME

SHYMAN - Sustainable Hydrothermal Manufacturing of Nanomaterials

TEAM

Promethean Particles with University of Nottingham and others

The process

Continuous hydrothermal synthesis produces nanoparticulate materials by mixing superheated or supercritical water flow with an aqueous flow containing a dissolved metal salt. So rather than slowly heating the entire contents of a batch vessel (called batch hydrothermal synthesis), two fluids are continuously mixed together. The problems around this process were solved during years of research at the University of Nottingham and the reactor configuration necessary for continuous production was demonstrated at bench (g/hr) and pilot scale (kg/day) before the SHYMAN project began.

Continuous hydrothermal synthesis offers a true alternative to other, chemical-intensive production methods because it is a genuinely continuous process and is chemically more benign.

Markets and impact

Among other nanoscale-products, Promethean is producing a copper ink for flexible circuitry and 3D printing. This has been a key part of moving from silver-based RFiD tags to copper, which is about 1/20th the cost of silver at wholesale prices. "A company in Japan is talking about making one billion RFID tags, that's just one client," says Lester.

Another big market is that for metal organic frameworks, whose applications include adsorbents like toxic chemicals, gas separation and drug delivery. The potential market value for all these nanomaterials is hundreds of billions of dollars, said Lester.

From a personal perspective, Prof. Lester is proud of what SHYMAN has achieved. "This technology was described as the 'Holy Grail' by a senior person working in the catalyst field. People had tried it and written it off because it was so difficult."

WINNER
YOUNG
INNOVATOR

SPONSORED BY

SOLIDWORKS

Home help

Future engineer develops facial recognition door entry system for the elderly

The winning entry to this year's Young Innovator category - a system aimed at helping vulnerable elderly people to live safely and independently in their own homes - provided the C2I judging panel with plenty of reasons to be optimistic about the future pipeline of engineering talent.

Inspired by the challenges facing his great Aunt Pat, who lives alone at home with dementia, Freddie Howells developed a facial recognition door entry system to protect her from unwanted visitors alongside a suite of home monitoring technologies to check up on her welfare.

Developed by Freddie when he was just 12 years old (he's now 14) the system was created using a Raspberry Pi microcomputer.

For the entry system a PIR motion sensor attached to the front door triggers a camera to take an image when motion is detected.

This is compared against a database of known faces and if the face is recognised, the visitor is prompted to scan their ID tag for 2 factor authentication. If the face and ID tag match, the door is opened via means of a 5V single channel relay attached to a 12V electric door strike. If they're not recognised or do not match, the user is prompted to call a number to gain access.

When the visitor gains access, a text is sent to the family alerting them to who has visited and when. At the same time an audio recording of the visitor's voice is played in the elderly person's room so they know who is visiting.

Freddie has also installed various monitoring devices around the home including a motion sensor which triggers a text alert if there is no motion for a period of time, and temperature and humidity sensors which will automatically turn on a fan if the temperature gets too hot. He's also installed a webcam which can be used for remote monitoring and a voice-activated intercom system that enables two-way communication without the need for the phone.

PROJECT NAME

Facial Recognition Door Entry System and Home Monitoring System for the Elderly

PARTNERS

Freddie Howells, CETEC - Centre for Excellence in Technology Enhanced Care

Whilst initially inspired by the challenges faced by his great Aunt, Freddie believes that his system could help ultimately improve the quality of life for many more people. Indeed, around one in six of over 80's are affected by dementia, and one third of these live alone.

"These people are vulnerable and often the cause of huge concern to family members who may well live great distances from their loved ones," he said. "If we are to enable individuals to live independently at home for longer then there is a need to embrace technology to support them."

Freddie has been supported throughout the project by assistive technology expert Firas Sarhan, director of the Centre of Excellence for Technology Enhanced Care (CETEC) at Barnet Southgate college in North London.

He explained that working with CETEC was particularly helpful in terms of developing the system for monitoring and controlling the temperature and humidity of the home, an important factor for any elderly or housebound people who might be particularly prone to chest infections.

"Working with someone like Firas, who is a leader in my project field, has provided me with the insight as to how this project could potentially be utilised in homes across the UK," he said.

Freddie added that working with Firas has also helped him understand how his future career might progress. "His input has helped me realise how my interests and skills can lead to a career in engineering and the multitude of areas in which an engineer can work that I hadn't considered before."

Freddie's mother Sarah Howells told The Engineer that Freddie has always been interested in engineering and been very creative since a young age. This interest was piqued partly by his introduction to Scratch, a block-based visual programming language aimed at children, by a family friend, Dr James Osborne, who is a senior lecturer at Cardiff University's National Software Academy. "Freddie quickly moved on to coding in Python and started exploring the world of Physical Computing which is really where his passion lies," she added.

Freddie is now exploring the world of wearable assistive technology and looking at how he can help both people with dementia and people with Parkinson's. "Ambitions wise, he is already talking about universities," said his mother. "He is keen to explore computer science and engineering but isn't sure exactly what path that will take him down, although I'm sure he'll have many options open to him!"

SOLIDWORKS® is proud to be associated with the

Young Innovator

AWARD CATEGORY

SOLIDWORKS delivers ongoing support to the engineering startup community through its Entrepreneur Program which provides new startup companies with **free 12-month licenses of SOLIDWORKS products for CAD, simulation, visualization, and more.**

Eligible early-stage hardware startups can benefit from SOLIDWORKS online training and design guidance from SOLIDWORKS engineers and technical managers at **no cost to help them succeed.**

SOLIDWORKS

The Engineer would like to thank the following organisations for their sponsorship and support for C2I 2019

HEADLINE SPONSOR

Frazer-Nash Consultancy Ltd

Frazer-Nash is a leading systems and engineering technology company. With over 800 employees, Frazer-Nash works from a network of ten UK and four Australian locations. Its consultants apply their expertise to develop, enhance and protect our clients' critical assets, systems and processes.
https://www.fnc.co.uk/

CATEGORY SPONSORS

Babcock International Group

Babcock is a leading provider of critical, complex engineering services which support national defence, save lives and protect communities. The company focuses on three highly regulated markets – defence, emergency services and civil nuclear – delivering vital services and managing complex assets in the UK and internationally.
https://www.babcockinternational.com/

Comsol

Comsol is the developer of COMSOL Multiphysics software, an interactive environment for modeling and simulating scientific and engineering problems.
https://www.comsol.com/

Solidworks

Dassault Systèmes SOLIDWORKS Corp. develops and markets 3D CAD design software, analysis software, and product data management software.
https://www.solidworks.com/

HVM Catapult

Established by Innovate UK, HVM Catapult is a network of manufacturing research centres established to bridge the gap between business and academia, helping to turn great ideas into reality by providing access to world-class research and development facilities and expertise that would otherwise be out of reach for many businesses in the UK.
hvm.catapult.org.uk/

Goodfellow

Goodfellow is a leading global supplier of metals, alloys, ceramics, glasses, polymers, compounds, composites and other materials to meet the research, development and specialist production requirements of science and industry.
www.goodfellow.com/

Mazak

Yamazaki Mazak was established in 1919 and has been contributing to the development of the machine tool industry as a leading global company. Yamazaki Mazak manufactures advanced machine tools such as multi-tasking centres, CNC turning centres, machining centres and laser processing machines as well as automation systems.

PARTNERS

Engineering UK

EngineeringUK is an independent, not-for-profit organisation. Its stated purpose is to promote the contribution that engineers, and engineering and technology, make to society.
www.engineeringuk.com/

EPSRC

The Engineering and Physical Sciences Research Council (EPSRC) is the UK's main agency for funding research in engineering and the physical sciences.
epsrc.ukri.org/