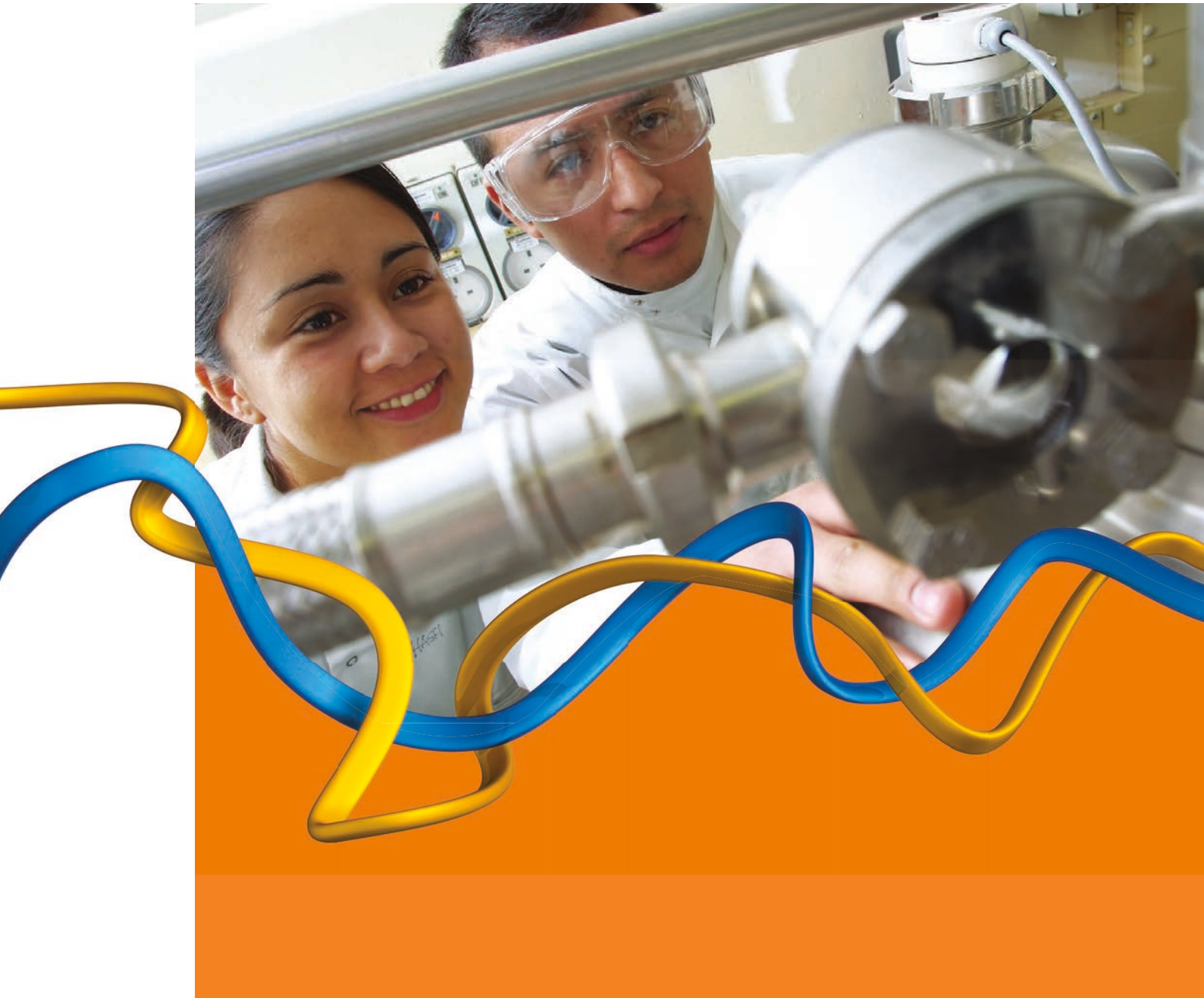
ROYAL ACADEMY OF ENGINEERING

AnnualReview

2016/2017



Strategic challenges

As the UK's national academy for engineering, we bring together the most successful and talented engineers for a shared purpose: to advance and promote excellence in engineering.

We provide analysis and policy support to promote the UK's role as a great place to do business. We take a lead on engineering education and we invest in the UK's world-class research base to underpin innovation. We work to improve public awareness and understanding of engineering.

We are a national academy with a global outlook and use our international partnerships to ensure that the UK benefits from international networks, expertise and investment.

We have four strategic objectives, each of which provides a key contribution to a strong and vibrant engineering sector and to the health and wealth of society

Make the UK the leading nation for engineering innovation

Supporting the development of successful engineering innovation and businesses in the UK in order to create wealth, employment and benefit for the nation.

Address the engineering skills crisis

Meeting the UK's needs by inspiring a generation of young people from all backgrounds and equipping them with the high quality skills they need for a rewarding career in engineering.

Position engineering at the heart of society

Improving public awareness and recognition of the crucial role of engineers everywhere.

Lead the profession

Harnessing the expertise, energy and capacity of the profession to provide strategic direction for engineering and collaborate on solutions to engineering grand challenges.

Front cover image courtesy of the University of Birmingham

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www.raeng.org.uk/publications/strategy-and-finance

Forewords

> **It is the Fellowship, with its broad range of expertise, that gives credibility and authority to our activities.**

Dame Ann Dowling OM DBE FREng FRS

President

In June 2016, the Academy celebrated 40 years since our founder Fellows were brought together for the first time by HRH Prince Philip The Duke of Edinburgh to create the Fellowship of Engineering. Since then, as our Senior Fellow, Prince Philip has given his time to the Academy tirelessly and generously and, as he steps back from public duties, we remain deeply grateful for all his encouragement and support.

The 40th anniversary gave us a good opportunity to take stock, assess our progress and look ahead to the next phase of our development. One theme became very evident: everything the Academy achieves is rooted in the leadership and enthusiastic participation of our Fellows. It is the Fellowship, with its broad range of expertise, that gives credibility and authority to our activities. Whether helping identify the next cohort of new Fellows, mentoring budding entrepreneurs, framing our policy advice to government, guiding our communications with the public through the media, supporting our vibrant research programmes, or steering our schools outreach – Fellows are the core of everything we do. I am very grateful to our Fellows who so generously give their time.

Over the year, two critical and significant developments in policy called for a profession-wide response. Following the results of the EU referendum, the Academy led a collaborative study that was published in the name of the 38 organisations that make up the engineering profession. Together, we undertook a very broad consultation right across the UK that provided the evidence for our report, *Engineering a future outside the EU*, which I handed personally to the Secretary of State for Exiting the EU. The report, which sets out the issues that are of concern to the engineering community, has been very well received in the profession and across government, and we have had a steady stream of meetings with key ministers and officials to discuss the points that it conveys.

Later in the year, the government published a Green Paper on industrial strategy, another issue of great importance across the engineering profession. We again joined forces to respond to the consultation, with workshops and a survey with some 1,200 individual responses providing the evidence for our submission. Again, the fact that the profession has spoken with a single voice on such a significant topic has been well received by ministers and we have had a number of meetings and workshops to follow up on our recommendations.

Not surprisingly, a critical issue highlighted in both reports is the shortage of people with engineering skills. The causes of this are long running and complex, and the Academy has identified seven factors that we are addressing in different ways under the banner of the *Engineering Talent Project*. Key among these is the need to address the perception of, and attitudes towards, engineering careers. There are many excellent programmes aimed at bringing engineering into the classroom but these are not having an effect at the scale needed, and the connections with schools are complicated – the Academy's *UK STEM Education Landscape* study identified that there are over 600 organisations involved in STEM education. So many options can make it difficult for schools to find out what is on offer and limits the opportunity to transfer best practice. To address this, the Royal Academy of Engineering and EngineeringUK are exploring how we might best work together to simplify and streamline our outreach to schools, for example through common messaging, a central education portal, and a focus on what teachers and students want. No one underestimates the challenge that this might present but, if the engineering profession works collaboratively once again, the increase in impact could have be significant.

> **Our education and skills and research programmes are greatly valued by schools, colleges and universities and continue to attract new support from engineering businesses and other partners.**

Philip Greenish CBE
Chief Executive

In her foreword, the President refers to two important reports to government in what has been a seminal year for the UK. Both were led by the Academy with the support of the larger engineering institutions, but presented in the name of all 38 bodies in the professional engineering community.

This reflects the growing need for our profession to speak with a coherent voice if we are to achieve real impact with policymakers on matters of strategic importance. This was also a key recommendation made by John Uff CBE QC FREng in his independent review of UK professional engineering, commissioned early in the year by the three largest engineering institutions.

The Academy has convened the profession and provided policy leadership for several years but the events of the last year and our response to them have provided added impetus to place this on a more strategic and systematic footing. This is critical if we are to contribute effectively to addressing the issues that might constrain the UK's ability to compete successfully on a global stage as we leave the EU.

Collaboration underpins all that the Academy does and is integral to the profession. The Trustee Board has been actively considering how the Academy can step up to the next level of effectiveness, impact and influence across all of the Academy's activities. We have already made considerable headway in expanding our global reach through our role in major new international programmes such as the Newton Fund and the Global Challenges Research Fund, all of which are delivered through partnerships. Our education and skills and research programmes are greatly valued by schools, colleges and universities and continue to attract new support from engineering businesses and other partners.

Throughout its relatively short life, the Academy has worked to secure its permanence. While it is the difference we make through our activities across the UK and beyond that matters, we need a well located and effective base from which we can plan and deliver our programmes. This year, we have secured a new 125-year lease on Prince Philip House and have completed the final phase of its refurbishment with the opening of the Taylor Centre. This provides us with a secure, high-quality home for the foreseeable future, which is close to Whitehall, Westminster and many principal partner organisations. Fellows have contributed significantly to this project over the years for which the President and I are most grateful. You will read within this report of the wide range of work that the Academy delivers within and from Prince Philip House.

The Academy has stepped up to many new challenges this year while consolidating its position. We look forward to working with our partners to increase the influence and impact of our profession in the challenging times to come.

Highlights of the year

MAKE THE UK THE LEADING NATION FOR ENGINEERING INNOVATION

43 EARLY-STAGE HUB MEMBERS HAVE RAISED MORE THAN **£30 MILLION** OF EXTERNAL FUNDING TO DATE

44 ACTIVE RESEARCH FELLOWSHIPS ACROSS **20** DIFFERENT UNIVERSITIES

181 LEADERS IN INNOVATION FELLOWSHIPS AWARDED IN **14** COUNTRIES

ADDRESS THE ENGINEERING SKILLS CRISIS

67,000 PUPILS HAVE BENEFITED FROM EDUCATION PROGRAMMES

28 NEW VISITING PROFESSORS APPOINTED, BRINGING THE TOTAL IN POST TO **68**

35 ENGINEERING LEADERS' SCHOLARSHIPS AWARDED

POSITION ENGINEERING AT THE HEART OF SOCIETY

250 MEDIA MENTIONS A MONTH ON AVERAGE

11,300 COPIES OF INGENIA SENT OUT QUARTERLY

265,000 VISITS PER MONTH TO THE ACADEMY WEBSITE

LEAD THE PROFESSION

35 MILLION PEOPLE EXPOSED TO THE ENGINEERING A FUTURE OUTSIDE THE EU REPORT

450 ATTENDEES FROM **40** COUNTRIES AT THE ENGINEERING A BETTER WORLD CAETS CONFERENCE

6,799 RESPONDENTS TO THE INCLUSIVE CULTURES PROJECT SURVEY

Make the UK the leading nation for engineering innovation

> From supporting researchers through their careers to helping to promote excellence in the profession, the Academy wants to make sure that brilliant innovators and entrepreneurs receive the support they need to translate their ideas into commercial success though products that can change lives.
>
> **Ian Shott CBE FREng, Chair, Enterprise Committee**

Enterprise Hub

In February 2017, the Enterprise Hub's new physical home, the Taylor Centre, was opened, providing a base for the Hub's community of talented innovators, mentors and investors. The Enterprise Hub forms a key part of the Academy's commitment to stimulating excellence and promoting creativity and innovation in engineering. It identifies the founders and leaders of tomorrow's high-tech companies and provides bespoke support and mentoring from the Academy's Fellowship.

Just after the opening, the fourth cohort of Enterprise Fellows and the second cohort of Enterprise Fellows supported by the Royal Commission for the Exhibition of 1851 were announced. The 12 Fellows will benefit from a comprehensive support package that includes seed funding, mentoring, and marketing and PR support. The Hub portfolio is diverse, supporting a wide spectrum of engineering and technology startups on their entrepreneurial journey, from antibacterial coatings for steel and 'smart glasses' for blind and partially sighted individuals, to energy-absorbing smart materials.

An attendee at the Taylor Centre launch event tries out Enterprise Hub member Mo-Sys Engineering's virtual reality technology © Rob Lacey

The Hub is becoming an increasingly global community. The Academy is now working with over 400 early-stage entrepreneurs from emerging economies around the world, including alumni of the Africa Prize for Engineering Innovation. They are being supported by the Shell Centenary Scholarship Fund, Newton Fund, and Global Challenges Research Fund (GCRF), which provides government funding to support cutting-edge research that addresses the challenges faced by developing countries.

The Academy's Launchpad Competition continues to encourage budding entrepreneurs between the ages of 16 and 25 to start a new business based on their engineering innovation idea. The 2016 winner, Michael Tougher, developed 'Dots', a novel musical technology that allows people to create music by positioning stackable buttons on a mat. Each button acts as a note and can be combined into entire chords.

Taylor Centre

The new Taylor Centre within Prince Philip House provides Enterprise Hub members with a place to meet, work and grow their businesses.

The opening of the Taylor Centre in February 2017 is the next step in the Academy's progress towards transforming Prince Philip House, the Royal Academy of Engineering's home since 2007, into a national forum for engineering.

Based in the lower ground floor of Prince Philip House, the dedicated centre offers state-of-the-art IT, audio-visual and conferencing facilities, hot-desking space and a number of different-sized meeting rooms.

The Taylor Centre provides a place where members can work, meet investors, attend events and receive training. By providing a physical space, together with funding and mentoring support, the Academy is leading the way in expanding the country's capacity for engineering innovation.

Plans for the new centre began with an enabling donation from renowned inventor and entrepreneur Dr John C Taylor OBE FREng, who has also lent his name to the Hub's new home. The redevelopment was also made possible with generous support from the late Geoffrey Argent FREng and The Wolfson Foundation, with equipment kindly donated by Toshiba UK.

The Enterprise Hub's new physical home, the Taylor Centre, offers Hub members a state-of-the-art space to work and network

The technology aims to empower people to create their own music without having to master complex musical instruments. Michael is now working with a number of Hub mentors to bring his product to market.

The Enterprise Hub Annual Showcase is the most significant event in the Hub's calendar. It provides Hub members with an opportunity to pitch their ventures to an audience with the aim of securing investments, clients or collaborations. The theme for the 2016 showcase was *Challenges of scaling up*. Gerard Grech, CEO of TechCity UK, delivered the keynote speech on the importance of building the capabilities of the next generation of technology entrepreneurs. Lesley Eccles, Founder and Marketing Director of fantasy sports marketplace FanDuel, led discussions that focused on breaking the growth barrier, drawing on her experiences of starting FanDuel and developing it into a world-class company.

The *Pathways to Growth* scheme, which previously supported training programmes to improve the skills of engineering entrepreneurs and engineers within startups, spin-outs and other small engineering organisations, has been refocused to meet the increasing challenges of scaling up. The new SME Leaders programme now aims to support the development of leadership skills through training courses, masterclasses and workshops, and mentorship.

Research

The Academy's research programmes contribute to engineering innovation by supporting excellent researchers throughout their careers.

The Research Fellowship scheme provides outstanding early-career researchers with five years' funding and mentorship from Academy Fellows to help awardees establish themselves as future research leaders. The scheme is highly competitive and 13 new appointments were made during the year. One of these Research Fellowships was supported by the Lloyd's Register Foundation and five were supported by the GCRF. The research objectives of the GCRF Research Fellows are focused on promoting the economic development and welfare of developing countries. The Academy's 44 active Research Fellowships are distributed across 20 different universities and a quarter have been awarded to women.

The Research Chairs and Senior Research Fellowships scheme, co-funded by industry, helps to establish and enhance world-leading, 'use-inspired' collaborative research programmes at UK universities. The five-year university–industrial partnerships have led to real impact, including acoustic damping systems for leaner, greener aero-gas-turbine combustion and improved survivability of protection structures. The scheme currently supports more than 45 partnerships covering a wide range of engineering disciplines and technology areas, from hip-replacement technology to machine learning. In the last year, four Senior Research Fellows have been promoted to professors and nine new awards were made; eight of these were with industrial partners that were new to the programme.

Another scheme bringing industry and academia together is the Academy's Industrial Fellowships scheme. It supports early- to mid-career academics wishing to undertake a collaborative research project in an industrial environment, which can help improve the quality and industrial relevance of their teaching and promote research collaboration. Eleven new Fellowships were awarded over the past year.

Launched in November 2016, Frontiers of Engineering for Development (FoE) is another of the Academy's GCRF programmes. FoE symposia are interdisciplinary, international events that attract diverse attendees from throughout engineering, including government, industry and academia. The events are held twice a year and bring together early- to mid-career engineers to network, engage and collaborate to tackle global grand challenges. At the end of each symposium, participants are offered the opportunity to apply for £20,000 seed funding to help kick-start a collaborative project inspired by the event. The first event took place in Cambridge in November 2016, resulting in 15 seed fund awards, and the second took place

At a glance

Research Chairs and Senior Research Fellows appointed in 2016-17

Professor Michalis Zervas, University of Southampton, SPI Lasers

Developing fibre-optic lasers of the future.

Dr Xibo Yuan, University of Bristol, Safran Electrical & Power UK

Reducing fuel consumption with more electric aircraft (MEA).

Dr Sophie Williams, University of Leeds, DePuy Synthes

Optimising reliability and performance of artificial hips.

Professor Stephen Roberts FREng, University of Oxford, MAN Group

Machine learning and data analysis techniques for large-scale, real-world applications.

Professor Omar Matar, Imperial College London, Petronas

From oil to toothpaste – multiphase fluid dynamics to help industry go with the flow.

Professor Hongbiao Dong, University of Leicester, TWI Ltd

Cracking the complexities of metal processing.

Professor Christoph Bruecker, City, University of London, BAE Systems

Developing aerodynamic skin inspired by nature.

Professor Robert Bowman, Queen's University Belfast, Seagate Technology

Developing new materials enabling advanced data storage for next-generation hard drives.

Professor Serafim Bakalis, University of Birmingham, Procter & Gamble

Modelling the real use of cleaning products to enable the development of sustainable goods.

The Frontiers of Engineering for Development symposia allow international development and engineering professionals from across the world to network and share ideas © Rob Lacey

in Edinburgh in February 2017, resulting in nine seed fund awards.

The Leverhulme Trust Senior Research Fellowships scheme, funded by the Leverhulme Trust, enables mid-career academics with a proven track record in research to be relieved of their day-to-day responsibilities in order to concentrate on research full time. Each Fellowship pays for a replacement academic to cover their teaching and administrative workloads for up to one year. In the last year, seven Leverhulme Trust Senior Research Fellowships were awarded.

This year, the Academy, the Royal Society and the British Academy, with support from the Leverhulme Trust, launched a new initiative: the APEX Awards (Academies Partnership in supporting Excellence in cross-disciplinary (X) research). The programme aims to demonstrate how researchers from different disciplines sharing a common vision can come together to generate creative and innovative solutions that benefit wider society, with a particular emphasis on the boundary between science and engineering and the social sciences and humanities. Each award will be up to £100,000 and can be held for a duration of 12 to 24 months. The award will primarily fund staff costs.

The Academy is partnering with the Government Office for Science to deliver a new UK Intelligence Community Postdoctoral Research Fellowship programme to promote unclassified basic research in areas of interest to the intelligence, security and defence communities. Applications were invited to address topics ranging from quantum and optical sensors to calculus of privacy, with successful candidates announced at the end of June 2017.

Some Academy-funded researchers had the opportunity to showcase their work at the annual STEM for Britain national poster competition, open to early-career researchers in science, technology, engineering and maths (STEM). At the March 2017 event, 60 engineering applicants from across the UK presented their research posters. Run by the Parliamentary and Scientific Committee in partnership with the Academy and other science and engineering organisations, the event provides a valuable opportunity for Parliamentarians to engage directly with scientists and engineers.

International activities

The Academy is a delivery partner for the government's Newton Fund, which supports science and innovation partnerships with emerging economies. One of the Academy's flagship Newton Fund activities is the Leaders in Innovation Fellowships (LIF) programme, which helps entrepreneurial researchers across the globe to commercialise innovations that address international development challenges. In March 2017, the third year of the LIF programme drew to a successful close after welcoming 181 Fellows from 14 Newton Fund partner countries to the UK, including the first attendees from Indonesia and Malaysia. At the Academy, they received an intensive course of training and coaching, masterclasses from Academy Fellows and opportunities to network with peers. The alumni from the second year of the programme reported raising over $6.5 million in funding following training from their coaches.

The Industry-Academia Partnership Programme is another Newton Fund scheme. This year, the programme funded a total of 46 bilateral collaborations with six countries. The China programme was particularly well subscribed and represents an important outcome of the Dowling Review Symposium, which was held in Beijing in July 2016 and encouraged both countries to share lessons on business-university collaboration.

Research Fellowships

Royal Academy of Engineering Research Fellowships are designed to promote excellence in any field of engineering.

The scheme provides support for high-quality engineers over a five-year period and encourages them to develop successful, independent academic research careers. The Fellowships can have a long-term impact on the Research Fellow's career and can be of great relevance to industry.

One such Fellowship was held by **Dr Paul Shearing** at University College London until December 2016. His research focused on tackling challenges in electrochemical energy conversion and storage, particularly improving the design of lithium-ion batteries, and he was promoted to Reader during the Fellowship. Dr Shearing has published more than 90 papers on his work in electrochemical storage and raised additional funding of over £9 million from Research Councils UK and industry. He won the Institution of Chemical Engineers' Young Chemical Engineer of the Year in Academia in 2014 and a RAEng Engineers Trust Young Engineer of the Year award in 2016. Dr Shearing believes that the resources, support and academic freedom afforded by the Research Fellowship were pivotal to these achievements.

Dr Paul Shearing

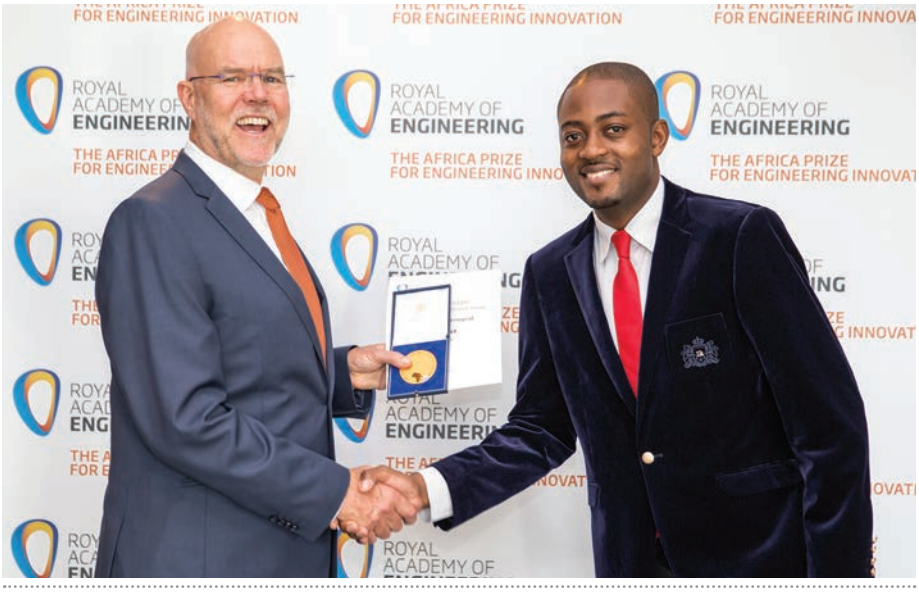
Dr Peter Gammon

Dr Peter Gammon completed his Research Fellowship at the University of Warwick in March 2017. His work focused on developing new electronic devices that can work in harsh environments, such as aerospace and electric vehicles. He developed novel silicon-on-silicon-carbide (Si/SiC) wafers that exploit the advantages of these semiconductor materials, which include higher voltages, currents and temperatures. The Si/SiC concept and the methodology for developing these wafers were developed within the time of Dr Gammon's Fellowship and have led to an optimised and subsequently patented device layout. Dr Gammon has since been awarded an Innovate UK grant and is involved in industrial projects with Thales Alenia Space and the UK Space Agency. He believes that his career developed at such a pace thanks "to the academic freedom and security that the Research Fellowship guarantees".

After a pilot phase that ran from 2013 to 2015, the Higher Education Partnerships in sub-Saharan Africa programme was able to scale up significantly, supported by funding from the Anglo American Group Foundation and the GCRF. The programme provides funding to nine hub universities in sub-Saharan Africa, which support a network of 62 additional spoke universities in 16 countries across the region. The hub universities undertake work placements with local industry partners, and in turn, share their experiences with the spoke universities through a series of workshops that they organise and fund. By forming and strengthening relationships between academia and industry, the programme aims to ensure that the higher education system in sub-Saharan Africa produces engineers with the skills and knowledge required to meet the needs of industry and to tackle local challenges.

In 2016, the second Africa Prize for Engineering Innovation was awarded to Arthur Zang, an innovator from Cameroon, for his heart-monitoring device, the Cardio-Pad. The small tablet device allows any medical professional to perform heart diagnostics at any location, which can then be sent to a cardiologist and interpreted in less than 20 minutes. Zang's innovation earned him a prize of £25,000, and three other finalists from Kenya, South Africa and Uganda each received £10,000 to support their businesses in the fields of health technology and energy access.

In early 2017, 16 entrepreneurs from eight countries in sub-Saharan Africa who have been shortlisted for the third Africa Prize attended a week of training in Kigali, Rwanda. The training allowed them to practise their pitches and meet inspiring local Rwandan innovators. An exciting partnership with HRH The Duke of York's Pitch@Palace series also resulted in all of those on the shortlist pitching their innovations at St James's Palace in London in March 2017.



Africa Prize winner Arthur Zang receives the award for his Cardio-Pad device from lead judge Malcolm Brinded CBE FREng

Address the engineering skills crisis

> The UK requires a highly skilled workforce of creative engineers and technicians. From learning resources for school pupils to grants and bursaries for engineering students, the Academy is ensuring that young people are aware of the opportunities to pursue engineering at each stage of their education.
>
> **Professor Helen Atkinson CBE FREng, Chair, Education Committee**

Visitors to the Academy's stand at the Big Bang Fair enjoy a demonstration of Marty the Robot, a programmable 3D-printed robot developed by Enterprise Hub member Dr Alexander Enoch of Robotical

Activities for schools

The Academy's *Connecting STEM Teachers* programme, which works to enhance the teaching and learning of STEM in schools across the UK, has expanded over the year and now has 45 teacher coordinators who support regional networks. The networks consist of 1,007 teachers from 504 schools across the UK, who receive training, free teaching and learning resources, and funding for collaborative projects between schools. It is estimated that over 150,000 school students have benefited from the programme since it was launched in September 2011.

The Academy's regional STEM support programmes, which provide opportunities for STEM engagement to students in disadvantaged areas of the UK, are now active in Lowestoft, Barrow-in-Furness and Stoke-on-Trent. These three programmes, which provide funding directly to schools to allow them to enhance and enrich their STEM curricula, are cumulatively working with 32 primary schools, 15 secondary schools and six post-16 colleges. To date, over 106,000 STEM learning opportunities for local students have been provided, with activities including after-school clubs, STEM challenge days, computing/robotics challenges and visits to local employers. Continuing professional development for teachers has been provided at all levels of education and engagement. To build links with local organisations, the Lowestoft project provided fully funded internships in the local energy industry for five 16 to 18 year old students over the summer in 2016. Following this pilot, the scheme is being expanded to provide placements for 25 students in 2017.

In the last year, the Academy has developed a new *Cyber security* resource to support the schools' roadshow, launched in February 2017 by BAE Systems, the RAF and the Royal Navy. The resource explores online safety and shows how engineers have applied their knowledge to improve the security of the internet. The resource will be an integral part of the roadshow, which is expected to travel to more than 400 schools across the UK. The Academy also developed and launched *Existence at the extreme*, its latest STEM teaching and learning resource. This resource gives students the opportunity to learn how engineering has provided solutions to allow people to live in extreme environments such as deserts, the Arctic and monsoon regions. Since its launch in September 2016, more than 525 resource boxes and associated training materials have been disseminated to schools.

To date, the Academy has distributed nearly 3,700 resource boxes to schools and the full suite of resources has been downloaded online more than 25,000 times.

Engineering education reports

Over the past year, the Academy has published two reports about the status of STEM education in the UK, from primary and secondary level to higher education and opportunities for graduates.

Published in May 2016 for the Lloyd's Register Foundation, *The UK STEM education landscape* report provided a detailed picture of the engineering and STEM education landscape: the issues that need to be addressed, the organisations involved and an analysis of gaps in provision. It highlighted the fact that many young people do not study STEM subjects beyond GCSE, despite over 10 years of activity from more than 600 organisations encouraging them to do so. The STEM community has been working hard for many years to improve the number of young people with the qualifications and interest to consider progressing into engineering occupations. The analysis in this report was undertaken to inform the wider community, so that it can make strategic decisions about focusing support in areas that will have the most impact on the engineering skills shortage.

Published in November 2016, *Employment outcomes of engineering graduates: key factors and diversity characteristics* investigated the employment destinations of recent engineering graduates from UK higher education institutions. The report presented a detailed analysis of the factors affecting engineering graduate employment and, for the first time, provided data on long-term graduate employment outcomes. The results showed the importance of engineering skills to the economy, with overall employment outcomes from engineering being very strong, compared to the overall graduate cohort. However, the results also highlighted stark differences in employment outcomes between engineering graduates of white and ethnic minority origin, finding that 71% of white engineering graduates find full-time jobs after six months compared with just 51% of Black, Asian and minority ethnic (BAME) students. The report concluded that further investigation into the impact of ethnicity and academic attainment on early employment prospects for engineering graduates is needed, with the Academy encouraging engineering employers to work to address these issues.

The employment outcomes of engineering graduates: key factors and diversity characteristics report found that engineering graduates are highly employable but that ethnicity is still a barrier © University of Birmingham

Attendees at the Visiting Professors' conference collaborate on a project held at one of the workshops © Rob Lacey

The Academy supported the national Big Bang Fair again this year, with a stand that showcased some of the work done by Enterprise Hub members and the Academy's Research Fellowships. This included Marty the Robot, a programmable 3D-printed robot developed for schools to help students learn to code by Enterprise Hub member Dr Alexander Enoch's company Robotical, and demonstrations of the uses of graphene. It is estimated that close to 10,000 people visited the Academy's stand over the four days of the fair.

Education for Engineering

The Academy-hosted alliance, Education for Engineering (E4E), brings together the 35 professional engineering institutions (PEIs), the Engineering Council and EngineeringUK to provide a single, coherent voice to government and the devolved assemblies on education and skills matters.

This year, much of the activity has centred on the skills implications of exiting the EU and coordinating the engineering profession's response to the skills elements of the government's industrial strategy Green Paper.

Another area of focus has been the creation of the new Institute for Apprenticeships. E4E has been presenting the profession's view on the functions and responsibilities of the institute. The engineering profession already makes a substantial contribution, not least through the Trailblazer Apprenticeship Standards development process, and is continuing its discussion with the institute on a range of issues around apprenticeship standards.

The institute will also take on responsibility for technical education, specifically the new post-16 routes proposed in Lord Sainsbury's skills review. The engineering community supported the Department for Education in the development of the T-levels by mapping the occupations for engineering and manufacturing, construction and the built environment, and digital.

Further and higher education

The Academy's Higher Education Employer Engagement Programme provides opportunities for undergraduates from underrepresented groups to improve their chances of gaining engineering employment after graduation. It provides them with a range of support activities such as interview techniques, CV writing, mentoring and networking events with employers.

The programme has moved into its second year and staged three events, in London, Derby and Leicester, which promoted a career in engineering to students from underrepresented groups. Working in collaboration with 13 employer partners, the project has engaged more than 300 students, 56 of whom have successfully secured graduate or placement positions in engineering companies.

In late 2016, the Academy launched *Higher Education Focus*, an interactive website that collates information and provides a hub for those teaching, studying, working or interested in engineering in higher education. The website includes links to relevant books, journals, online resources and reports; information about schemes for industry, undergraduates, postgraduates and academic staff; information about the Engineering Education Research Network; details of upcoming events; and weekly news updates.

For the past 18 months, the Academy has been tackling the challenge of developing a robust process for measuring teaching quality. A new university teaching measurement framework has been created for the evaluation of teaching achievement during faculty appointment and promotions procedures. The framework can be used across any discipline, not just engineering,

Transforming attitudes to engineering

The Engineering Talent Project (ETP) aims to communicate the excitement of engineering and breadth of opportunities it offers.

ETP, the Academy's programme to address the engineering skills crisis and public attitudes towards engineering as a career, has made considerable progress over the past year. The project has attracted the support of seven major engineering businesses and a comprehensive research study has provided greater understanding of the young people whom the Academy hopes to reach, and their perceptions of an engineering career.

One of the Academy's main areas of focus has been on developing a suite of creative materials for a communications campaign that will challenge the typical view of engineering and inspire young people to find out more. A variety of ideas have undergone qualitative testing with the target audience, which has provided further insight into the perceptual shift required to engage them. The next steps for the project include the development of a more detailed media plan of where the adverts will appear, the adverts themselves, and commencement of a wider round of consultation and testing of the branding, messaging, storyboard and script.

The other elements of the project focus on increased engagement with schools through EngineeringUK's Tomorrow's Engineers programme; a policy and public affairs programme to address structural barriers, such as teacher shortages in key subjects and poor careers guidance in schools; and a concerted effort to improve workplace cultures so that employers are attractive to the current and next generation of engineers.

as appointment and academic progression is mainly set at institution level. The framework is also intended to be used for academics in both 'teaching and research' and 'teaching-only' posts.

For the past year, the framework has been piloted and evaluated by a consortium of 16 leading universities from across the world. The Academy has hosted expert workshops to gain feedback on the current template and a finalised version is due to be published in late 2017.

Visiting Professors

The Academy's Visiting Professors (VP) scheme is a highly valued industry-into-academia initiative to enhance both student learning and the employability of engineering undergraduates at UK universities. The Academy's VPs play a key role in embedding an industry-focused teaching approach into the academic environment.

This year, 28 new VPs were appointed, bringing the total on the scheme to 68 VPs across 37 different universities. The Academy hosted the annual VP conference in November 2016 on the theme of *How they do it elsewhere*. For the first time, the conference brought together VPs with academics from the Academy's international programmes, enabling them to network, take part in workshops and panel discussions, and share approaches from the UK and overseas.

Bursaries and professional development

The Academy's Engineering Leaders Scholarship programme (formerly the Engineering Leadership Advanced Awards) identifies and supports outstanding engineering undergraduates with the potential to become future leaders in industry and act as inspiring role models for the next generation of engineers. Over the past year, 35 award holders each received £5,000 to undertake an accelerated personal development programme, along with an annual training weekend and mentorship.

The Academy has a long history of developing industrial leaders who will drive future UK growth. The Sainsbury Management Fellowships (SMF) scheme, funded by the Gatsby Charitable Foundation with the personal support of Lord Sainsbury and the Engineers in Business Fellowship (the charity arm of the SMF programme), enables engineers who have high career potential to undertake a full-time MBA programme at a leading internationally renowned business school. Nine new awards were made during the year. Following the completion of their MBA, the awardees are supported by an extensive network of SMF alumni, managed by the charity.

Alumni also play a key role in supporting a wide range of Academy activities, including the Engineering Leaders Scholarships and the Enterprise Hub.

At a glance

Education programme highlights

Over the past year:

Nearly **1,000** free resource boxes have been given out to schools.

The *Connecting STEM Teachers* programme has worked with more than **1,000** teachers from over **500** schools.

The Engineering Leaders Scholarships scheme has supported **35** undergraduates.

The Academy has supported **68** Visiting Professors at **37** UK universities.

Nine Sainsbury Management Fellowships have been awarded.

More than **300** students have been part of the Higher Education Employer Engagement Pilot Project.

Position engineering at the heart of society

> The Academy's Fellowship is a hugely valuable resource, enabling us to ensure that the voice of engineering is heard and heeded in the public domain. The Academy has become a key contributor to the development of national policy, and the work we do to raise the public profile of our profession – both in the UK and internationally – has enjoyed great success, although there is so much more to be done.
>
> **Professor John Loughhead OBE FREng, Chair, Engineering Policy Committee**

Policy

This year, a key theme for the Academy's policy work has been digital systems and data. Following on from the publication of the *Connecting Data* report in September 2015, the Academy held workshops that considered aspects of cyber security and resilience and how to use data to create wealth. The first of these workshops investigated how digital control systems and the Internet of Things can be developed to incorporate higher safety standards, something that is vital as more and more critical systems are being connected. The second workshop explored how data generates value and where innovations have led to new ways of prompting wealth creation, for both individual companies and the UK economy as a whole. To mark the one-year anniversary of the publication of the report, a panel discussion, *Creating value from data through statistics and engineering*, was held jointly with the Royal Statistical Society.

As part of the Engineering and Physical Sciences Research Council's first Robotics Week in June 2016, the Academy hosted a debate on the ethics of autonomous systems: *Robots: faithful friend or existential threat?* The discussion covered the technical, economic, social and legal aspects of the development of artificial intelligence, focusing on the sufficiency of existing legislation against cybersecurity attacks and the ethical frameworks that should guide developments in artificial intelligence. It has since been developed into a study that will consider how regulations in autonomous systems might impact on UK businesses.

On the subject of energy, the Academy published *Living without electricity*, a report that was put together with Lancaster University and the Institution of Engineering and Technology. The report detailed the loss of virtually all modern infrastructure in Lancaster for four days in December 2015, caused by unprecedented flooding in north Lancashire and Cumbria. Professor Roger Kemp MBE FREng, a Professorial Fellow at Lancaster University, used this local crisis as an opportunity to observe how modern society copes without a regular supply of electricity. He first wrote a blog post, which was followed by a workshop and publication of the report. Stories about the report's findings were featured in the *Guardian* and the *Sunday Times* and the subject has been aired at a number of meetings of emergency responders and planners around the country.

Better delivery of health and social care was addressed through a year-long project that brought together engineers and some 50 people involved in service improvement in the NHS. A series of workshops examined how systems-thinking methods drawn from engineering could help to transform the quality of health and care in the UK and reduce costs. The shared learning from this work has been distilled into a 'primer', a document that will enable this engaged community to explore and promulgate the approach in their NHS and academic institutions.

The Academy's Panel for Biomedical Engineering held a three-day conference, hosted by Imperial College London, on medical imaging and interventions for cancer for early-career researchers and their mentors in September. The conference was designed to support the career development of postdoctoral researchers by giving them the opportunity to showcase their work, improve networking skills and receive guidance from leading experts.

The Academy was commissioned by the Department for Transport and the Department of Energy and Climate Change (now the Department for Business, Energy and Industrial Strategy) to put together a report on the sustainability of liquid biofuels that will provide evidence to support policy developments in this area. Work on the study progressed throughout the year under a working group of Academy Fellows and experts, supported by Academy staff, and the final report will be published in summer 2017.

Academy awards evening

The MacRobert Award 2016 winning team from Blatchford receives the gold medal from HRH The Princess Royal and the President

In June 2016, the President was joined by over 400 guests to celebrate the best in UK engineering at the Academy's annual Awards Dinner, held at the Pavilion at the Tower of London.

The evening saw the announcement of the MacRobert Award, the UK's longest-running and most prestigious prize for innovation in engineering. HRH The Princess Royal and the President presented the prize to the winning team from Blatchford for the development of its Linx limb system, a prosthetic with smart robotics that constantly monitor and adapt to movement, making walking and other movement more natural for lower-leg amputees.

Apple's Chief Design Officer Sir Jonathan Ive KBE HonFREng was guest of honour at the event and presented MacRobert Award finalists Jaguar Land Rover and Siemens Magnet Technology, as well as Blatchford, with a certificate.

A number of other prizes were presented throughout the evening. Professor Danielle George MBE, from the University of Manchester, received the Rooke Award for her contribution to the public promotion of engineering, including the Royal Institution Christmas Lectures that she presented on engineering. The Major Project Award was presented to a team from BAE Systems' AI (Applied Intelligence) Labs for its Intermediate Frequency Modem System, which was a key component of the technology used by the Rosetta spacecraft to study the comet 67P/Churyumov-Gerasimenko. The Prince Philip Medal, the Academy's highest individual accolade, went to Dr Jonathan Ingram for his groundbreaking work on BIM (building information modelling).

The Silver Medals, which are awarded to outstanding individuals in recognition of their personal contributions to UK engineering, were presented to:

Dr Damian Gardiner, a research scientist and Business Development Manager at Johnson Matthey, which acquired his University of Cambridge startup company, ilumink Limited, in 2015. Dr Gardiner developed a unique method of printing 'liquid crystal' material onto any surface using an ink-jet printer, a secure, economical and practical way of security-tagging products such as cosmetics, perfumes, drugs and banknotes.

Dr Demis Hassabis, Co-founder and CEO of Google's DeepMind subsidiary, which has made a number of pioneering breakthroughs in artificial intelligence (AI). Founded in 2010 and acquired by Google in 2014, DeepMind's AlphaGo project successfully beat the world's number one Go player, long seen as a grand challenge of AI research, in a contest in Seoul in 2016. It was watched online by 280 million viewers.

Professor Tong Sun, Director of the Photonics and Instrumentation Research Centre at City, University of London. She was the first female professor to be appointed at the university's School of Engineering (as it then was) in its 100-year history and is an international leader in the use of optical fibre sensors to monitor sensitive equipment, particularly in extreme conditions.

Established with the generous support of the Worshipful Company of Engineers, the RAEng Engineers Trust Young Engineers of the Year awards are given to UK engineers in full-time higher education, research or industrial employment, who have demonstrated excellence in the early stage of their career. The five awards were presented to Dr Sithamparanathan Sabesan from the University of Cambridge, Dr T Ben Britton from Imperial College London, John Collins from Arup, Orla Murphy from Jaguar Land Rover and Dr Paul Shearing from University College London. Dr Sabesan also won the Sir George Macfarlane Medal for demonstrating excellence in the early stage of his career.

At a glance

Event highlights

April 2016

Fellows' visit to British Airways Engineering.

May 2016

Self-driving cars – a safe bet? – East Midlands regional lecture by Professor Tim Gordon, Head of School of Engineering, University of Lincoln.

September 2016

Research Forum – exhibiting the work of the Academy's funded researchers.

October 2016

Breaking the code – held as part of the *Ingenia* live! series with presentations from Professor Dino Distefano from Facebook, Dr Marily Nika from Google, and Dr Danny Tarlow from Microsoft Cambridge.

Space missions – the what, how and why – regional lecture by Professor Matt Perkins FREng.

November 2016

In conversation with MacRobert 2016 Award winners: Blatchford – the development of the world's most advanced prosthetic limb.

Hinton lecture – Engineering the future of data – Professor Sir Nigel Shadbolt FREng, Professor of Computer Science at the University of Oxford and Principal of Jesus College, explored how advances in computing are transforming the world we live in.

January 2017

Fellows' Day – a special event for Fellows, highlighting the Academy's recent and current work.

March 2017

Delivering the nation's flagships – joint annual lecture with the Royal Society of Edinburgh given by Archie Bethel CBE FREng FRSE, Chief Executive of Babcock International Group plc.

Engineering the future – lecture by Warren East CBE FREng as part of the *View from the top* series.

Engaging through the media

The Academy's communications activities have grown steadily throughout the year, with an increase in media coverage and audiences engaged with the Academy through social media and public engagement.

Academy activities continue to be promoted through a wide range of traditional and social media. Highlights this year include the President appearing on *Desert Island Discs* on BBC Radio 4 during the week when she was formally appointed to the Order of Merit by Her Majesty The Queen. Several other Fellows were profiled in the media this year, including Dame Judith Hackitt DBE FREng in the *Financial Times*' At Home feature and Dr Dame Sue Ion DBE FREng FRS, who also appeared on *Desert Island Discs*.

Over the course of the year, the Academy was mentioned in national and regional print and online media more than 3,000 times – an average of 250 mentions a month – and has contributed to 43 TV broadcasts and 113 radio broadcasts. These ranged from the Enterprise Hub Showcase being featured on the Sky News' technology show *Swipe* to Optos founder Dr Douglas Anderson FREng being interviewed for the *Daily Express*, 10 years on from winning the MacRobert Award.

Engineering a future outside the EU, the profession-wide report coordinated by the Academy following the EU referendum (see page 19), reached an estimated audience of up to 35 million people when it was published, through coverage including articles in the *Daily Telegraph* and *Financial Times*. Deputy CEO Dr Hayaatun Sillem was interviewed about the report on BBC World News and BBC Radio 4's *Today* programme.

The Academy's work has also been publicised in connection with cultural events this year. The 20th Century Fox film *Hidden Figures* offered an excellent opportunity to promote the Academy's diversity and inclusion work. The film is based on the true story of a group of African American women who worked for NASA as 'human computers' in the 1950s and 1960s. Head of Diversity Bola Fatimilehin was interviewed by both the *Daily Telegraph* and the *Guardian*, and she and Surrey Satellite Technology's Anita Bernie spoke on Radio 4's *Today* programme about the importance of diverse teams in engineering.

Public affairs

The outcome of the referendum on the UK's membership of the EU and the appointment of Prime Minister Theresa May and her government team provided the backdrop to much of the Academy's external relations activity during the last year. The Academy took advantage of opportunities to engage widely across government following publication of the joint professional report, *Engineering a future outside the EU*, which resulted in the profession having considerable interaction at the highest level with those departments preparing the UK's position for the negotiations.

The Academy has long called for industrial strategy to be a central priority of government. As such, the creation of the Department for Business, Energy and Industrial Strategy was very welcome news,

Speakers at the first UK schools screening of *Hidden Figures*, organised by the Manchester United Foundation: (l–r) Elspeth Finch (Chair of the Royal Academy of Engineering Innovators Network), Anita Bernie (Director of Spacecraft Platforms at Surrey Satellite Technology), Ginny Buckley (broadcaster and motoring journalist), Hazel Macnamara (Audit Partner at PwC), Professor Karen Holford FREng (Deputy Vice Chancellor at Cardiff University) and Rachel Riley (mathematician and presenter of Channel 4's *Countdown*)

and the Academy quickly built on its existing relationship with the new Secretary of State, Greg Clark MP, actively working with him on a number of issues including the engineering skills shortage.

Public engagement

The *Ingenious* public engagement grant scheme supports projects across the UK that engage people with engineering in creative ways, and gives the engineers involved opportunities to develop their communication and engagement skills. Now in its 10th year, the scheme has funded more than 189 projects, reached over 2.5 million members of the public, and worked with more than 5,000 engineers.

Projects that ran over the last year included the eTunes: build your own electro-acoustic guitar workshop series, where participants worked together with engineers to learn basic acoustic, circuit design and electromagnetic theory. The project culminated in a gallery exhibition and video documentary at Edinburgh College of Art, and participants took part in busking sessions at a local shopping centre.

Ingenious also funded Survival Village, an initiative organised by SMASHfest, which promotes STEM through art and design. The festival took place in Deptford, London, and was designed to increase diversity and widen participation in STEM subjects within one of London's most disadvantaged boroughs. Using a disaster scenario that focused on the aftermath of a volcanic eruption, participants explored engineering solutions to loss of shelter, power and clean water. Survival Village will also visit other underserved areas of London through a series of mini-festivals and workshops.

The Academy also participated in public engagement activity at science festivals. In September 2016, the Academy hosted a stand at *New Scientist Live*, based on the theme *Superhuman vs. Superhero*, for which Disney/Marvel permitted the Academy to use imagery of its popular superhero characters. Visitors to the stand were able to get hands-on with the latest brain- and body-enhancing technology, such as state-of-the-art prosthetics, a mind-controlled game, a working *Iron Man*-inspired helmet and glove, and a demonstration of smart materials.

The same theme was explored at Cheltenham Science Festival through an Academy-hosted panel discussion with Professor Mark Miodownik FREng that explored the latest engineering developments and asked how much human enhancement is too much.

Visitors to the Academy's stand at *New Scientist Live* view a demonstration of an *Iron Man*-inspired helmet and glove designed by Matt Dickinson, a lecturer in computer-aided engineering at Lancaster University who received an *Ingenious* grant in 2014

Celebrating engineering – the Queen Elizabeth Prize for Engineering

Queen Elizabeth Prize for Engineering winners (l-r) Dr Michael Tompsett, Professor Eric Fossum, Professor Nobukazu Teranishi and Dr George Smith

The Queen Elizabeth Prize for Engineering is an international £1 million prize that rewards and celebrates engineers responsible for a groundbreaking innovation that has been of global benefit to humanity.

On 1 February 2017, Lord Browne of Madingley FREng FRS, Chairman of the Queen Elizabeth Prize for Engineering Foundation, announced the winners of the 2017 Queen Elizabeth Prize for Engineering. The winners were four engineers from across the world, Professor Eric Fossum (USA), Dr George Smith (USA), Professor Nobukazu Teranishi (Japan) and Dr Michael Tompsett (UK), who together were responsible for the creation of digital imaging sensors, technology that has transformed medicine, science, personal communication and entertainment on a global scale.

The announcement took place at Prince Philip House in the presence of HRH The Princess Royal. It received global coverage, reaching an international audience of around 1.3 billion people across a range of media. These included BBC channels, Sky News, *Financial Times*, *The Times*, *Daily Telegraph* and *Daily Mail*; *Time* and *Forbes* in the USA; NHK and Fuji TV in Japan; and Phoenix TV in China.

On the day, 15-year-old Samuel Bentley from Wales was also named as the winner of the international *Create the Trophy* competition. Samuel's trophy design, inspired by Snowdon, was chosen from thousands of entries from 14 to 24 year olds in 32 countries around the world.

Create the Trophy winner Samuel Bentley receives his prize from HRH The Princess Royal at the announcement of the winners of the third Queen Elizabeth Prize for Engineering on 1 February 2017

Entries to the competition were made via a bespoke design app, launched in 2016 and free to download, which allowed entrants to easily create and submit their 3D designs. Samuel's winning design will be 3D printed by BAE Systems and presented to the 2017 Queen Elizabeth Prize for Engineering winners at a ceremony at Buckingham Palace in late 2017.

Alongside the biennial award, the prize is committed to encouraging young people to pursue careers in engineering. The Queen Elizabeth Prize for Engineering Global Engineering Ambassadors Network is an international community of young engineers from business and academia that plays a vital role in expanding the worldwide recognition of the prize. The ambassadors are role models and connect with peers around the world to promote engineering excellence and inspire the next generation, embodying the objectives of the prize.

Samuel Bentley's winning trophy design, based on Snowdon, which was created using the *Create the Trophy* app

Lead the profession

> The Academy has taken a leadership role across the profession in many areas, from assessing the impact of leaving the EU on engineering to a collaborative approach to diversity and inclusion. It has actively sought engagement from engineers and engineering employers across all of its activities to ensure that its work informs, supports and represents the profession as inclusively as possible.

Allan Cook CBE FREng, Vice President for Committee Coordination

Engineering the Future

Following the referendum vote for the UK to leave the EU, the Academy led work on the *Engineering a future outside the EU: securing the best outcome for the UK* report, which assessed the potential impacts on engineering of the UK leaving the EU.

The report was produced by an alliance of the UK's professional engineering organisations representing over 450,000 engineers. It drew on wide-ranging consultation with engineers from all corners of the profession, including industry, academia and the public sector.

A key finding was the need to maintain the supply of engineering skills to support the world-class quality and success of UK engineering companies and universities. In response, the report called on government and the engineering community to work together to take decisive action on the domestic engineering skills crisis and advocated straightforward solutions, such as temporary visas for skilled engineers from EU countries with the specialist skills that the UK lacks.

The report also highlighted how critical innovation is to the UK's economy and productivity. It addressed the role that EU support and collaboration has played in contributing to the UK's globally excellent and highly productive research and innovation base, and the risks posed by losing access to EU research and innovation funding programmes.

Capitalising on the strong policy recommendations outlined in the EU report, the Academy has been well-positioned to make informed contributions to government policy. The President met the Secretary of State for Exiting the European Union, David Davis MP, and other ministers and senior officials in relevant government departments, to emphasise the importance of engineering and ensure that it is fully recognised in forthcoming negotiations. The coming together of the engineering profession to produce a collective view was universally welcomed.

Throughout the consultation process, one opportunity was repeatedly highlighted: the development of a new industrial strategy by the government, in partnership with academia and industry, as a route to enabling engineering to maintain and increase its contribution to economic development and social progress after the UK leaves the EU. Therefore, when the government announced a nationwide consultation on industrial strategy in January 2017, the announcement was welcomed by the Academy and hailed as a major opportunity to reinvigorate the engineering and manufacturing sectors. Under the leadership of the Academy, the 38 national organisations representing the engineering profession again joined

The LGBT engineers who took part in the *What's it like?* film series increasing the visibility of LGBT people in engineering

forces to commission a survey and a series of workshops to respond collectively to the consultation.

Statement of Ethical Principles for the Engineering Profession

Within the past year, the *Statement of Ethical Principles for the Engineering Profession* has been revised. A joint working group was established in late 2016 to review the Statement to ensure that it remains fit for purpose. It was also an opportunity for the Academy to maintain a leadership role on ethics within the profession.

This joint publication between the Academy and the Engineering Council was first published in October 2005 and was last revised in 2014. It is intended to be a statement of the values and principles that guide engineering practice and should supplement the codes of practice published by the professional engineering institutions (PEIs).

Diversity and inclusion

Structural changes have been made to the Academy's diversity programme in response to recommendations made in an evaluation of its first phase, which ended in March 2016. The *Diversity Programme Report*, published in June 2016, captured the work of the programme from 2011 to 2016 and sets out the new strategic aims for the second phase of the programme:

- Challenge the status quo.
- Lead the profession.
- Sustain and extend networks.
- Communicate and consult.
- Publish measures and benchmarks.

The Academy's Diversity Leadership Group was restructured to become the Diversity and Inclusion Leadership Group (DILG) to have an increased focus on inclusion and provide opportunities for a larger number of companies to be actively involved in the programme. The DILG also comprises a small strategic steering group, which is supported by five industry-chaired action groups that each focus on a specific work theme: measurement, inclusive recruitment, procurement, inclusive cultures and communication approaches.

The Academy collaborated with the Science Council to create a *Diversity & Inclusion Progression Framework* for professional bodies that was launched in December 2016. The framework is a simple tool to help organisations plan and prioritise their diversity and inclusion activities in eight areas that are relevant to professional bodies, such as governance and leadership, awards and grants, and employment. Academy staff will use the framework in internal action planning during 2017 and will support the PEIs in their own framework rollout. The Academy's Engineering Diversity Concordat work with the PEIs has been brought under the Engineering the Future umbrella in order to reconnect with PEI presidents and chief executives.

As part of a growing focus on aspects of diversity beyond gender, a series of online videos profiling lesbian, gay, bisexual and transgender (LGBT) engineers was launched by the Academy, in partnership with InterEngineering and Mott MacDonald. Launched as part of LGBT history month, the *What's it like?* video series features 20 successful LGBT engineers, working in a variety of roles and settings, who share their stories of being LGBT in an engineering environment and encourage others to 'be yourself'. The films aimed to inspire prospective engineers who are LGBT, as well as existing engineers who may wish to come out or transition at work. The launch event for the films was supported by Past President Lord Browne of Madingley FREng FRS.

At a glance

Responses to consultations and inquiries

April 2016

Responses to inquiries from the House of Commons (HoC) Science and Technology (S&T) Committee into robotics and AI; the HoC Transport Committee on rail technology: signalling and traffic management; and a submission to the European Commission's call for ideas on a European Innovation Council.

June 2016

Response to the Higher Education Data and Information Improvement Programme as part of the subject coding reform.

July 2016

Response to the National Infrastructure Commission (NIC) consultation on 5G.

September 2016

Responses to inquiries from the HoC S&T Committee on leaving the EU: implications and opportunities for science and research; the Public Bill Committee on the Higher Education and Research Bill; and the Business, Innovation and Skills Committee on industrial strategy.

October 2016

A joint submission from the four UK National Academies to the HoC S&T Committee on the role and priorities of UK research and innovation.

November 2016

Response to the Lords Internal Market Sub-Committee inquiry on UK-EU trade in engineering services.

January 2017

Responses to inquiries from the HoC S&T Committee on closing the STEM skills gap.

February 2017

A submission to the Department for Business, Energy and Industrial Strategy review of the Small Business Research Initiative.

March 2017

Responses to the HoC S&T Committee inquiry into research integrity; and the UK higher education funding bodies consultation on the second Research Excellence Framework.

Engineering a Better World

In September 2016, the Academy hosted a major conference that was organised as part of its presidency of CAETS, the global federation of engineering academies.

The *Engineering a Better World* conference brought together over 400 global engineering leaders, international development practitioners and policymakers, industry stakeholders, government officials, and engineers from the developing world to highlight the vital importance of engineering in achieving the UN's Sustainable Development Goals (SDGs).

The conference was delivered as part of the Academy's portfolio of activities under the Global Challenges Research Fund. It focused on making links between the engineering and international development communities in the UK and the Global South, and building the capacity and networks of the UK's engineering research community to tackle global challenges.

The Academy developed a suite of communications materials that were launched at the conference, including:

- A short film, *Because Engineering*, which featured contributions from Bill Gates, Marissa Mayer, CEO of Yahoo, and Jack Ma, CEO of Alibaba, among others. The film was aimed at young people and showcased the human impact of engineering. It reached more than two million people on social media.
- A thought leadership publication with contributions from leaders including Dr Jan Eliasson, Deputy Secretary General of the UN, and Barbara Frost, CEO of WaterAid. The comment pieces in the publication explained how engineering contributes to the UN's SDGs. As well as being available at the conference, it was distributed with the December issue of the Academy's *Ingenia* magazine to over 11,000 contacts; another 10,000 copies will be distributed to the Academy's corporate and higher education contacts in the UK and internationally.
- A research study that demonstrated the link between investment in engineering and economic growth. An interactive map has been produced to showcase the key results of the research.
- An international survey of young engineers, which garnered responses from over 1,000 engineers on questions relating to their thoughts and perceptions of the engineering challenges and opportunities within their own countries.

Yassmin Abdel-Magied, Founder of Youth Without Borders, speaks at the *Engineering a Better World* conference

Since the conference took place, an *Engineering a Better World* LinkedIn platform has been created to maintain contact and discussion with networks across the Academy's international programmes. The Academy also held an event during Global Entrepreneurship Week that asked the question: Can startups drive sustainable development? The event consisted of a panel discussion that explored how engineering entrepreneurs in the UK and in developing countries can help deliver the SDGs.

Young engineers at the conference were able to meet and work with peers and stakeholders from 40 different countries

Greatly enhance the Academy's delivery capability

> The credibility of the Academy with its partners, funders and the engineering community at large is underpinned by its ability to deliver. Its people and processes have to be more agile and responsive to take advantage of opportunities to work with others who share an agenda for the future of engineering. This is an exciting time for the Academy and strengthening capabilities in these areas will be crucial to its continuing success.

Dr Frances Saunders CB FREng, Chair, Membership Commitee

(l–r) The Academy's first Director of Strategy and Deputy CEO Dr Hayaatun Sillem, CEO Philip Greenish CBE, the President Professor Dame Ann Dowling OM DBE FREng FRS, Ian Shott CBE FREng, Professor Haroon Ahmed FREng, and Shirin Dehghan, founder of telecoms company Arieso, at the launch of the new Taylor Centre © Rob Lacey

This year, the Academy appointed its first Director of Strategy and Deputy CEO. The post was created to increase the Academy's capacity to deliver its ambitious five-year strategy.

Dr Hayaatun Sillem, formerly the Academy's Director of Programmes and Fellowship, took up her post on 24 May 2016. The new role involves overseeing the implementation of the five-year strategic plan and, alongside the CEO, leading cross-Academy change and modernisation projects. It has also involved working closely with Fellows, Academy staff and partner organisations to increase the impact and enhance the contribution that engineering makes to society, both within and beyond the UK.

Dr Sillem continues to lead the Academy's Fellowship activities, award schemes and research policy, and has taken on a strategic oversight role across the Academy's increasing portfolio of programmes.

Redevelopment

After an extensive period of being closed for refurbishment, Prince Philip House reopened in early 2017. The basement and mezzanine floors of the building have been remodelled to accommodate the Taylor Centre (see page 7), and a modern kitchen has been installed to replace the previous facilities, which were almost 30 years old. RAE Trading Ltd (RAET), the Academy's trading subsidiary, was effectively dormant throughout most of the year, but has recommenced its operations since the reopening. RAET provides high-quality catering for the Academy's events and meetings in Prince Philip House, as well as marketing the building as an events venue, primarily to the corporate sector. RAET gift aids around £500,000 per annum to the Academy as unrestricted income.

The redevelopment has also resulted in significant investment being made to Prince Philip House's IT infrastructure. This has included new Wi-Fi networks for guests and the Taylor Centre, and state-of-the-art projectors and audio-visual equipment in meeting rooms and the Taylor Centre.

At the beginning of 2017, the Academy entered into a new 125-year lease with the Crown Estate, securing the home of the Academy for the future.

Development

In the last year, the Academy secured £5.1 million in new commitments for education, engagement, enterprise and research programmes. Support came from corporates, charitable foundations and individuals, including Fellows. The continuing generosity of all donors and supporters is greatly appreciated, as is the assistance of the Development Advisory Board.

Education programmes received major support during the year. Royal Dutch Shell confirmed a further year of support for the *Connecting STEM Teachers* programme and Boeing UK joined as a new supporter. BAE Systems confirmed a new round of support for the Academy's STEM education and outreach activities, while the Sir John Fisher Foundation, Drayson Foundation, Comino Foundation and Ogden Trust were among the many organisations also supporting the Academy's school STEM programmes. The Motorola Solutions Foundation continued its valuable support of the Academy's further education programmes by providing funding for continuing professional development for lecturers.

The Academy secured a major grant from

Fellowship engagement

The Fellowship is the heart of the Academy and a better level of engagement with a greater number of Fellows serves to advance the Academy's aims and strategic objectives.

The Academy's Fellowship engagement is led by Vice-President Professor Richard Williams OBE FREng, Principal and Vice-Chancellor at Heriot-Watt University.

Over the past year, focus has been placed on broadening the regional footprint of Academy activity. Fellows around the country have been given support to organise activities for Fellows in their local area. Activities have successfully taken place in the East Midlands, the North East and Yorkshire, while regional Fellows' lunches have taken place in Cardiff, Edinburgh, Coventry and Leeds.

One of the highlights of activity this year was Fellows' Day, held in January 2017. More than 160 Fellows and their guests attended this informal and social occasion. The day provided Fellows with an opportunity to learn about recent Academy activities and meet Trustees, other Fellows and Academy staff and talk to them about how to get involved in leading and shaping Academy work.

The event also gave Fellows the chance to see the recently opened Taylor Centre and to hear about the Academy's plans for using it as the home of the Enterprise Hub (see page 7). Fellows and their guests heard from the President, who was joined on stage by Enterprise Hub members who spoke about the difference the Hub has made to them and their companies. The event ended with a talk by Professor Williams, who highlighted the importance that the Fellowship plays in Academy activities.

Enterprise Hub member Dr Sam Chapman of KENOTEQ (right) demonstrates his sustainable bricks to Ian Ritchie CBE FREng FRSE and Professor Richard Williams OBE FREng FRSE at Fellows' Day

the European Regional Development Fund for the Enterprise Fellowships programme. The Enterprise Hub's partnership programme, which along with Fellows' pro-bono support is helping to enhance and expand the Hub's activities, attracted new multi-year funding from Weir Group, BP, Ultra Electronics and QinetiQ.

International programmes received funding from the Shell Centenary Scholarship Fund, which supported the Africa Prize for Engineering Innovation. Mott MacDonald supported the thought leadership publication that was published as part of the CAETS conference *Engineering a Better World*, as well as a series of inspiring video profiles of LGBT engineers as part of the Academy's diversity and inclusion work.

Long-time corporate supporter Atkins was headline sponsor for the Academy's Awards Dinner 2016, and BAE Systems, BP, GKN, Jaguar Land Rover, Lockheed Martin and Petrofac were silver sponsors. BAE Systems also continued its support of the Academy's quarterly magazine *Ingenia*, as did Arup and Rolls-Royce.

This year, the Academy published *Build a Better World*, a publication that marked the launch of an initiative to develop lifetime and legacy giving to help the Academy achieve its ambitions.

The Academy's education programmes benefited from considerable support over the past year

At a glance

Examples of new funding

Enterprise

The Reece Foundation provided funding for Enterprise Fellowships for engineering graduates in the North East of England.

Research

Man Group supported a new Academy Research Chair in Machine Learning at the University of Oxford to develop machine learning and data analysis techniques for large-scale, real-world applications, including financial modelling.

Education

Boeing UK granted funding to expand the *Connecting STEM Teachers* programme and create new STEM teaching and learning resources

Awards

The Wellcome Trust supported a bursary programme to enable delegates from developing countries to attend the 2016 CAETS conference.

Public engagement

BAE Systems, GKN, QinetiQ, Weir Group and URENCO supported the Academy's Forum for Engineering events programme.

Trustee Board

The Trustee Board comprises 12 Trustees elected by and from the Fellowship and is chaired by the President, Professor Dame Ann Dowling.

Chair

Professor Dame Ann Dowling OM DBE FREng FRS
President

Vice Presidents

Allan Cook CBE FREng
Vice-President for Committee Coordination

Professor Richard Williams OBE FREng FRSE
Vice-President for Fellowship Engagement

Members

Professor Colin Bailey FREng

Professor Sir Michael Gregory CBE FREng

Norman Haste OBE FREng

Dr David Hughes FREng

Dr Robert Joyce FREng

Professor Elaine Martin OBE FREng

John Robinson CBE FREng

Dr Frances Saunders CB FREng

Professor Liz Tanner OBE FREng FRSE

Paul Westbury CBE FREng

New Fellows 2016

The Academy's Fellows represent the nation's leading engineering researchers, innovators, entrepreneurs, and business and industry leaders. Each year, 50 Fellows are elected by peer review from nominations made by existing Fellows. They are distinguished by the title Fellow of the Royal Academy of Engineering and the postnominal FREng. These were the new Fellows announced at the Academy's AGM in September 2016; their titles were correct at the time of their election.

Fellows

Richard Barber FREng

Group Head of Engineering, MMD

Alan Belfield FREng

Group Board Director, Arup Group

Professor Andrew Bell FREng

Chair in Electronic Materials, University of Leeds

Jane Butler FREng

Vice-Dean (Enterprise), Faculty of Engineering, University College London

Gavin Campbell FREng

Director (Quality, Airworthiness and Technology Strategy), Bombardier Aerospace

Andrew Carlick FREng

Chief Executive Officer, DBD Group Holdings

Richard Clegg FREng

Managing Director, Lloyd's Register Foundation

Graham Dalton FREng

Chief Executive, Defence Infrastructure Organisation, Ministry of Defence

Professor Giles Davies FREng

Professor of Electronic and Photonic Engineering and Pro-Dean for Research and Innovation, Faculty of Engineering, University of Leeds

Steven Dearden FREng

President, Nuclear Submarines, Rolls-Royce plc

Chris Dulake FREng

Major Projects Portfolio Director, Mott MacDonald

Professor Ahmed Elghazouli FREng

Professor of Structural Engineering and Head of Structures Section, Imperial College London

Professor Mojtaba Ghadiri FREng

Professor of Chemical Engineering, University of Leeds

Anthony Graham FREng

Chairman, UK Naval Engineering, Science and Technology

Professor Sarah Hainsworth FREng

Professor of Materials and Forensic Engineering, University of Leicester

Antony Harper FREng

Head of Research and Technology, Jaguar Land Rover

Sir David Higgins FREng

Non-Executive Chair, High Speed Two (HS2)

Professor Sri Hinduja FREng

Professor of Manufacturing Technology, University of Manchester

Professor David Howard FREng

Professor of Electronic Engineering and Founding Head of Department, Department of Electronic Engineering, Royal Holloway, University of London

Professor Ron Hui FREng

Chair Professor of Power Electronics, The University of Hong Kong and Imperial College London

Professor David Hutchins FREng

Professor of Engineering, University of Warwick

Professor William Jones FREng

Professor of Combustion and Deputy Head of Thermofluids Division, Imperial College London

Robert Keiller FREng

Chair, Scottish Enterprise

Simon Knight FREng

Naval Engineering Director, Babcock International

Dr Barbara Lane FREng

Fellow of Fire Engineering, Technology Group Leader, Arup; Visiting Professor, University of Edinburgh

Professor Gary Lye FREng

Professor and Head of Department of Biochemical Engineering, University College London

Thomas McMichael FREng

Former Engineering Director (Combat Air), BAE Systems Military Air and Information, BAE Systems

Dr Paul Miller FREng

Secretary (voluntary), Douglas Bomford Trust; Director, Silsoe Spray Applications Unit Ltd

Professor Toby Mottram FREng

Douglas Bomford Trust Professor of Farm Mechanisation, Royal Agricultural University

Alan Newby FREng

Director, Aerospace Technology and Future Programmes, Rolls-Royce plc

Professor Bucur-Mircea Novac FREng

Professor of Pulsed Power, Loughborough University

Professor Paul O'Brien CBE FREng FRS

Professor of Inorganic Materials, University of Manchester

Professor Peter O'Hearn FREng

Engineering Manager, Facebook; Professor of Computer Science, University College London

Roderick Rainey FREng

Director, Rod Rainey and Associates Ltd.

Professor Mark Rainforth FREng

Professor of Materials Science, University of Sheffield

Dr Mark Raiss FREng

Engineering Director, Civil Infrastructure, EMIA, AECOM

David Rugg FREng

Engineering Senior Fellow, Rolls-Royce plc

Professor Mark Sandler FREng

Professor of Signal Processing, Queen Mary University of London

Catriona Schmolke FREng

Senior Vice President, Jacobs Engineering

Rakesh Sharma FREng

Chief Executive, Ultra Electronics Holdings plc

Professor Ian Smith FREng

Professor of Applied Thermodynamics and Director of the Centre for Positive Displacement Compressor Technology, City University London

Michael Tuke FREng

Founder and Chairman, MatOrtho Ltd

Gavin Twidale FREng

Chief Engineer, Land (UK), BAE Systems

Professor Robert Wood FREng

Associate Dean of Research, and Director, National Centre for Advanced Tribology, University of Southampton

Professor Philip Woodland FREng

Professor of Information Engineering, University of Cambridge

Sir Hossein Yassaie FREng

Tech Entrepreneur and Investor

Air Marshal Julian Young CB OBE FREng

Chief of Materiel (Air), Defence Equipment and Support, Ministry of Defence

Professor Zi-Qiang Zhu FREng

Royal Academy of Engineering/Siemens Research Chair and Head of the Electrical Machines and Drives Research, University of Sheffield

International Fellows

Professor Charbel Farhat FREng

Vivian Church Hoff Professor of Aircraft Structures, and Chair, Department of Aeronautics and Astronautics, Stanford University

Dinesh Verma FREng

IBM Fellow, IBM Thomas J Watson Research Center

Honorary Fellows

Thomas Heatherwick CBE RDI HonFREng

Founder, Heatherwick Studio

Professor Peter Jost CBE HonFREng*

President, International Tribology Council and World Tribology Congress

*elected before Professor Jost sadly passed away on 7 June 2016

Awards

2016 MacRobert Award

The premier award for innovation in UK engineering, with a £50,000 prize, awarded annually to a team of engineers for an exceptional engineering innovation that has been both commercially successful and delivers benefits to society. The MacRobert Award is supported by the Worshipful Company of Engineers.

Awarded to:

Blatchford for its Linx limb system, the world's most intelligent prosthetic limb

2016 RAEng Engineers Trust Young Engineers of the Year and Sir George Macfarlane Medal

These awards are supported by the Worshipful Company of Engineers and recognise the potential of engineers working in the UK who have demonstrated excellence in the early stage of their career. The overall winner receives the Sir George Macfarlane Medal.

Awarded to:

Dr Sithamparanathan Sabesan, Chief Executive Officer, PervasID
Winner of the Sir George Macfarlane Medal

Dr T Ben Britton, lecturer, Department of Materials, Imperial College London

John Collins, senior engineer, Arup

Orla Murphy, acoustic engineer, Jaguar Land Rover

Dr Paul Shearing, senior lecturer in chemical engineering, University College London

2016 Silver Medals

For an outstanding personal contribution to UK engineering by an early- to mid-career engineer resulting in market exploitation. Up to four medals may be awarded in any one year.

Awarded to:

Dr Damian Gardiner, Research Scientist/Business Development Manager, Johnson Matthey

Dr Demis Hassabis, Co-founder and CEO, Google DeepMind and Vice President Engineering, Google

Professor Tong Sun, Professor of Sensor Engineering, City, University of London

2016 President's Medal

Awarded to an Academy Fellow who has contributed significantly to the Academy's aims and work through initiative in promoting excellence in engineering.

Awarded to:

Dr Ian Nussey OBE FREng

2016 Sir Frank Whittle Medal

Awarded to an engineer resident in the UK whose achievements have had a profound impact upon their engineering discipline.

Awarded to:

Professor Roger Sargent FREng, Emeritus Professor of Chemical Engineering and Senior Research Fellow, Imperial College London

2016 Prince Philip Medal

Awarded biennially to an engineer of any nationality who has made an exceptional contribution to engineering.

Awarded to:

Dr Jonathan Ingram, CSO and Founder, Silent Sensors Ltd

2016 Major Project Award

The award recognises the contribution of a team of up to five UK-based engineers who have delivered a major engineering project that has had a substantial impact on society.

Awarded to:

Intermediate Frequency Modem System, BAE Systems AI Labs:
Nick James
Matthew Gore
Mark Westcott

2016 Rooke Award

The prize is awarded to an individual, small team or project, based in the UK, that has supported the Academy's aims and work through their initiative in promoting engineering to the public.

Awarded to:

Professor Danielle George MBE, Professor of Radio Frequency Engineering, University of Manchester

2016 Colin Campbell Mitchell Award

For an engineer or small team of engineers who have made an outstanding contribution to the advancement of any field of UK engineering.

Awarded to:

Ultrahaptics:
Professor Sriram Subramanian
Dr Ben Long
Tom Carter

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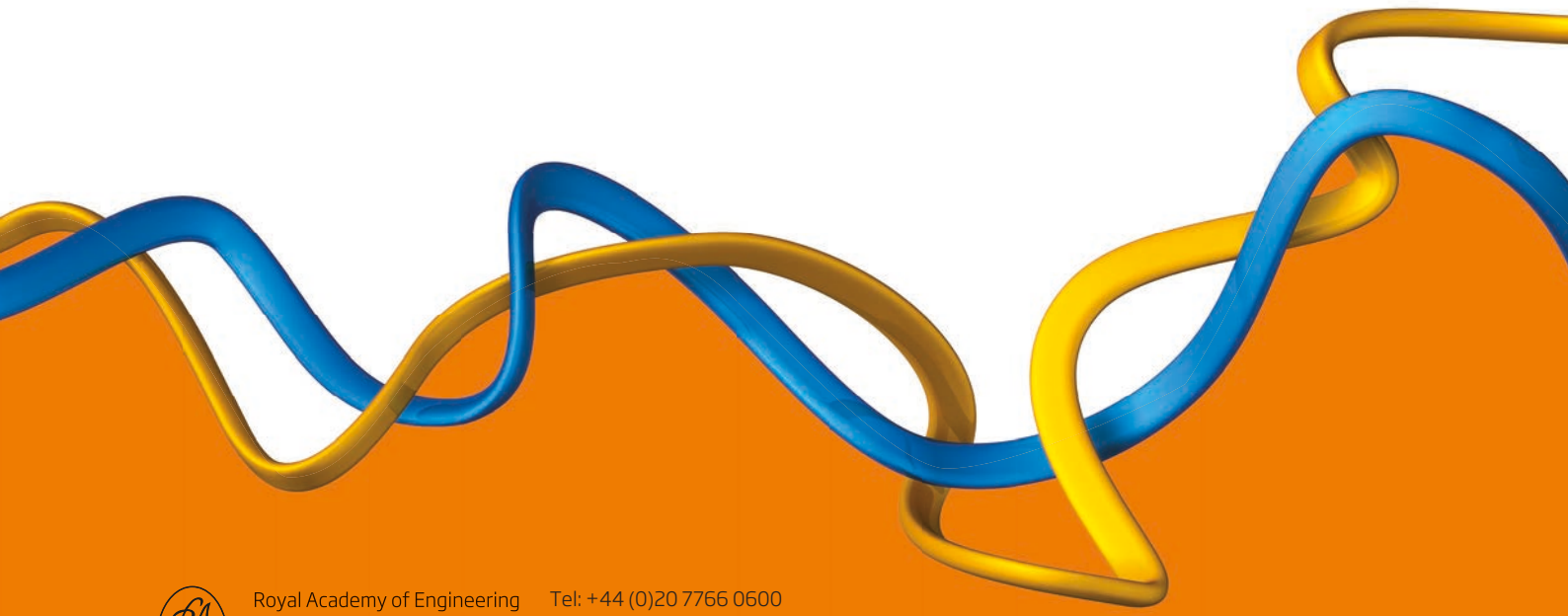

Royal Academy of Engineering
Prince Philip House
3 Carlton House Terrace
London SW1Y 5DG

Tel: +44 (0)20 7766 0600
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