DEPARTMENT OF ENGINEERING

NEWS

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£16M Boost for UK Robotics

A safer route to a nuclear future?

Infrastructure revolution

Top honour for Engineering alumna

UNIVERSITY OF CAMBRIDGE

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Cover photo: A student inside a reinforcement cage that fibre optic cabling is being attached to. By Dr. Mohammed Elshafie

Editors, Jacqueline Saggers and Ann Lynn
Department of Engineering
University of Cambridge
Trumpington Street
Cambridge CB2 1PZ
Telephone: +44 (0)1223 748228
Email: marketing@eng.cam.ac.uk
Website: www.eng.cam.ac.uk

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Building our alumni community – the results of our survey

In the last edition of the newsletter, we invited alumni to contribute to an online survey. We received very useful and detailed feedback on the undergraduate course, which we have fed into the Teaching Office. We were relieved to find that all but one respondent thought that the course was useful and particularly appreciated its breadth throughout their careers.

Useful pointers were given on what they found to be missing from the course during their careers and what we should think about including in the future. Some of these gaps have already been plugged since the respondents graduated; the feedback provided useful confirmation that we were on the right track. Other gaps need attention and the feedback has catalysed new debates in the Department.

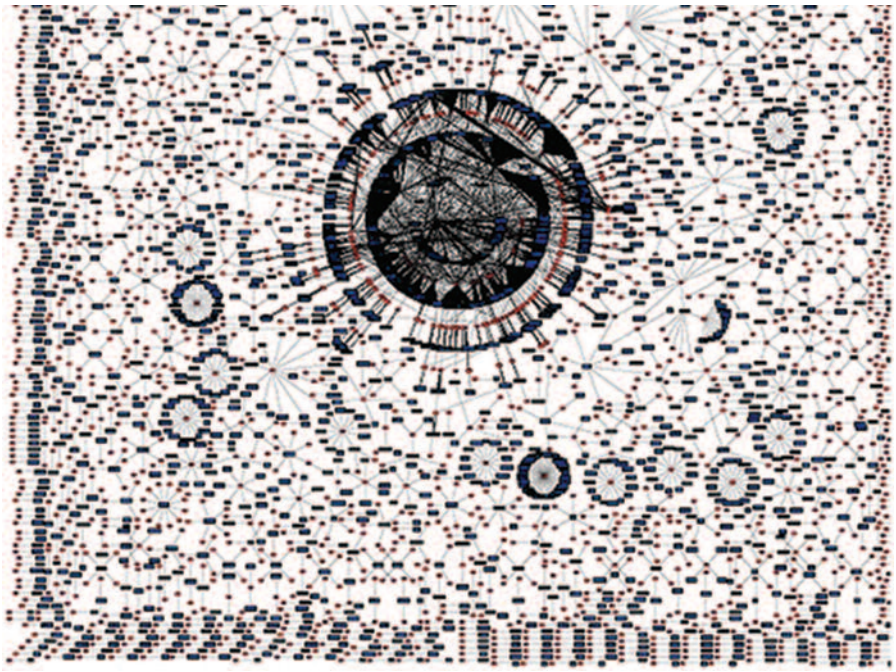
Appetites and suggestions for Cambridge engineering events for alumni were highly varied, so any Engineering events that we develop in future will always target minority interests. This means that our focus will probably remain on the University Alumni Weekend, but we are always open to suggestions from regional alumni groups or those with shared special interests.

We asked about social media and found that a third of respondents reported that they used LinkedIn. Follow up discussions with current undergraduates, recent graduates and staff in the Department confirms that LinkedIn is preferred for professional social networking after graduation. We have joined forces with Dr Alexander Van de Putte, founder of the LinkedIn University of Cambridge Engineering Alumni group, to develop our profile there. There are already around 2000 members and we are hoping that the majority of alumni will sign up over coming years so that this becomes the forum for future consultations and debates. Please join us in the Cambridge University Engineering Alumni group at www.linkedin.com.

Our research shows that Twitter is also widely used by many undergraduates, recent graduates and media professionals. We have experimented and found that Tweets have a significant effect in propagating our news stories and promoting engineering to a wider audience. Please follow us at www.twitter.com/cambridge_eng.

Completing our launch into social media is our library of engineering-related photographs which can be accessed at www.flickr.com/cambridgeuniversity-engineering. There are over 1000 images on view, ranging from prizewinning photographs of engineering research and activities through to student projects and department personnel.

Finally, we would like to congratulate Dr Michael Purshouse who has been elected President of Cambridge University Engineers' Association, in succession to Major-General K John Drewienkiewicz. See page 4.



Zoubin Ghahramani – 'Internet search queries' An image of internet search queries where each user is represented as a red dot and each blue dot is a term (or phrase) they searched for. Terms are connected to each other through similar users, and users are connected through similar terms.

An integrated engineering department founded on core strengths spanning all engineering disciplines and also cross-connected by an integrated undergraduate course and four strategic research themes:
- **Energy, transport and urban infrastructure**
- **Uncertainty, risk and resilience**
- **Bioengineering**
- **Inspiring research through industrial collaboration.**

Use a laser, save a tree

Laser un-printers that can remove toner from scrap paper so that it can be used again may be coming to an office near you in the future, results from a new Cambridge study show.

Dr Julian Allwood, Leader of the Low Carbon Materials Processing Group, and David Leal-Ayala, a PhD student in the group, tested toner-print removal from paper by employing a variety of lasers.

The results showed that toner-print can be removed effectively without causing significant paper damage, allowing the paper to be reused, without being discarded, shredded or sent to a recycling plant.

Coupled with advances in low-energy laser scanning technology, copiers and printers, the research means that toner-removing devices may be a common sight in offices around the country in the future.

Julian said: "What we need to do now is find someone to build a prototype. Thanks to low-energy laser scanners and laser-jet printers, the feasibility for reusing paper in the office is there."

The implications of the study also extend beyond the workplace and into the forest. Reducing the use of trees from the paper lifecycle is a real possibility. Along with saving forests from being used for new paper, reusing paper could save an additional 50-80% in carbon emissions over recycling.

The study poses the question of what would happen if paper was unprinted and reused instead of recycled. The action of removing toner with a laser would remove four steps from the paper production cycle: forestry, pulping, paper making and disposal by incineration or landfill.

Julian added: "Material recovery through reusing eliminates the forestry step from the life cycle of paper and eradicates emissions arising from paper incineration or decomposition in landfill."

With the aid of The Bavarian Laser Centre, a total of 10 laser setups spanning a range of strength and pulse durations were tested in the study. The lasers also spanned the ultraviolet, visible and infrared spectrum. The paper used in the experiments was standard Canon copy paper with HP Laserjet black toner, common in offices around the world.

Once the paper was exposed to the laser, the samples were then analysed under a scanning electron microscope and subjected to colour, mechanical and chemical analyses.
The study predicts that the emissions produced by the pulp and paper recycling industry could be at least halved as a result of paper reuse. "This could represent a significant contribution towards the cause of reducing climate change emissions from paper manufacturing" Julian said.

The toner print removal project was discussed by Julian along with his work on ways to recycle rare metals much more efficiently, on the BBC World Service programme 'One Planet' available on BBC iPlayer at the link below.

www.bbc.co.uk/iplayer/episode/p00n6z6d/One_Planet_Rare_metals_and_smart_lizards/

Parmee Prize awarded to research student

Felice Torrisi, of the Electrical Engineering Division's Nanomaterials and Spectroscopy Group, has been awarded this year's Parmee Prize for Entrepreneurship and Enterprise for his project on graphene printing technology.

SIR CAM

Graphene has recently attracted a strong interest among science and technology researchers, industries and policymakers for its unparalleled potential in many technologies including renewable energies, energy storage, flexible electronics and smart textiles. The judges acknowledged that Felice's team have made significant progress in one of the key challenges towards real commercialisation of graphene - namely the preparation of highly pure graphene printable inks and printed eletronic devices. This opens up realistic opportunities for economic production of flexible electronics and smart textiles with superior performances, establishing a radical change in the future of electronics.

The Parmee Prize for Entrepreneurship and Enterprise was established four years ago by William Pitt Fellow, Richard Parmee, to foster entrepreneurship among junior members in Pembroke College. The winner is awarded £1000 along with the opportunity for mentoring and advice from the judges to take the project forward.

Professor Daniel Wolpert has been elected a Fellow of the Royal Society

Professor Daniel Wolpert, Fellow of Trinity College, is a world leader in the computational study of sensorimotor control and learning, transforming our understanding of how the brain controls movement.

Combining theoretical and behavioural work, he has placed the field of sensorimotor control firmly within the probabilistic domain and shown how neural noise plays a pivotal role in determining both how we process information during action and how we generate actions. Professor Wolpert, of the Department of Engineering, is a recipient of a Wellcome Trust Programme Grant to study the computations the brain performs when controlling our movements.

Sir Paul Nurse, President of the Royal Society said: "Science impacts on most aspects of modern life, improving our understanding of the world and playing an increasing role as we grapple with problems such as feeding a growing global population and keeping an ageing home population healthy. These scientists who have been elected to the Fellowship of the Royal Society are among the world's finest. They follow in the footsteps of luminaries such as Newton, Darwin and Einstein and I am delighted to welcome them into our ranks."

Undergraduates collaborate with Jaguar Land Rover

A group of engineering undergraduates visited the Jaguar Land Rover Product Engineering Centre in Warwickshire as part of their final-year projects.

Students, supervisors and JLR engineers at the Heritage Motor Centre. From left to right: Will Graham, Adrian Iles, Michael Sutcliffe, Will Graham, Matthew Wraight, Michael Harrison, David Cole, Wasim Sarwar, Adrian Gaylard, Aylmer Johnson, Phil Barber, Andreas Flouris, Andrew Bell, Adam Southgate, Theo Cassell, Zetong Chen, Paul Hartley, Andrew Foster, (Paul Robertson absent).

The students have been working on their projects in collaboration with Jaguar Land Rover and travelled to Warwickshire with their supervisors for a progress meeting with JLR engineers. The morning was spent touring relevant parts of the engineering facilities. Everyone then moved to the adjacent Heritage Motor Centre for lunch, followed by presentations from each student. The presentations provoked very constructive discussion amongst everyone present.
The students and projects were:

- Matthew Wraight and Andrew Bell – Brake disc dirt shield design.
- Michael Harrison and Will Graham – The effect of vehicle aspect ratios on aerodynamic drag.
- Andreas Flouris – Lightweight load floor design.
- Zetong Chen – Speed over ground sensor.
- Paul Hartley – Brake pedal feel.

The projects have been successful in forging new links between the Department of Engineering and Jaguar Land Rover, in addition to providing the undergraduates with industrially-relevant and challenging projects.

Further projects for 2012/2013 have been proposed and it is hoped that these will provide similar opportunities for current third year students.

New President for Engineers' Association

Dr Michael Purshouse has been elected President of Cambridge University Engineers' Association, in succession to Major-General K John Drewienkiewicz.

Dr Purshouse won a British Aircraft Corporation Industrial Scholarship to the Department from 1970-1973, completing his PhD here in 1977. His extensive career in engineering has seen him honoured for his involvement in developing naval marine programmes for the Royal Navy. In recent years he has been involved in the development of open electronic architectures with Thales UK, until his retirement earlier this year. Dr Purshouse was elected a Fellow of the Royal Academy of Engineering in 2007. He has served on the RAEng External Affairs Committee and on the Science & Technology Facilities Council's Education, Training and Careers Committee.

The Cambridge University Engineers' Association works alongside the Cambridge University Engineering Society to provide a link between students, alumni and the Cambridge University Departments of Engineering and Chemical Engineering, maintaining connections between the Departments and the engineering profession as a whole.

www.cuengineeringsociety.org.uk www-g.eng.cam.ac.uk/cuea

Professor DameAnn Dowling featured on BBC Radio 4's 'The Life Scientific'

Each week, Professor Jim Al-Khalili talks to leading scientists about their life and work, finding out what inspires and motivates them and asking what their discoveries might do for mankind. In one of his interviews he talked to Professor Ann Dowling, Head of the Department of Engineering, about mathematics, engines and how she always wanted to do something useful.

Professor Dowling and her team worked on The 'Silent' Aircraft Initiative which had a bold aim - to develop a conceptual design for an aircraft whose noise would be almost imperceptible outside the perimeter of a daytime urban airport. This required radically different aircraft and engine designs. Professor Dowling and her team proved it is possible to build an aircraft that barely makes any noise. She discussed with Professor Jim Al-Khalili how her design for a silent aircraft could improve the quality of life for millions of people living near airports worldwide and why the project never got off the ground.

http://www.bbc.co.uk/programmes/b01m5gth

Olympic medal success for Department

Rowers Tom James and George Nash helped Team GB bring in their largest Olympic medal haul for over 100 years at London 2012.

Tom James MBE (Trinity Hall, 2002) repeated his success in Bejing four years ago by winning a second gold as part of the Men's Coxless Fours alongside Andrew Triggs Hodge, Peter Reed and Alex Gregory. A postbox in Tom's home town of Coedpoeth, Wrexham, was painted gold in his honour and Royal Mail issued a celebratory first class stamp featuring a photograph of the foursome. After the final, Tom commented: "I can't describe what this atmosphere is like. It's beyond words, it's epic, it's magic, it's emotional. The crowd is phenomenal. I'm so excited to be here and so proud."

George Nash (St Catharine's, 2008) earned himself a bronze medal in the Men's Pair with partner Will Satch, describing his Olympic experience as "awesome". The newly-paired duo stormed into third place less than half a second behind the French and were heartily congratulated by the winning New Zealanders. Sir Steve Redgrave, five-time Olympic champion and BBC Sport analyst, said: "What a fantastic performance and a brilliant bronze. That was one we didn't expect." Having taken a year out to concentrate on his rowing, George has now returned to the Department of Engineering to complete his degree.

Of the other Engineering Department alumni who competed in the games, Julia Bleasdale (Pembroke, 2000) gained 8th place in the finals of both the Women's 5000m and 10,000m; cyclist Emma Pooley (Trinity Hall, 2001) was 6th in the finals of the Women's Road Time Trial; Andrew Baddeley (Caius, 2000) came 10th in his semi-final of the Men's 1500m; and American rower Jake Cornelius (Emmanuel, 2006) narrowly missed out on a bronze medal for the US team in the Men's Eight.

ROYAL MAIL

"What a fantastic performance and a brilliant bronze."
Sir Steve Redgrave

Engineering student gains Cabinet Office work placement

Marcos Pelenur, a PhD student at the Centre for Sustainable Development, spent a three month work placement with the Behavioural Insights Team in the Cabinet Office as a Research Fellow.

The Behavioural Insights Team was established to help the UK Government develop and apply lessons from behavioural economics and behavioural science to public policy making.

Marcos supported the Behavioural Insights Team with the evaluation of their Green Deal incentive trials, and with the development of new trials around Smart Home Heating. This involved using Marcos' primary research work which investigates the link between household perspectives towards energy consumption and energy efficiency technology adoption.

Marcos was inspired to seek the work placement after attending the Professional Development Policy Seminar for Engineers, which was organised by the Centre for Science and Policy (CSaP) and supported by the Department of Engineering and the Institution of Engineering and Technology (IET).

He commented: "The work placement was a fantastic experience. It was really rewarding helping to shape policy papers and I encourage others interested in public policy to engage with the civil service."

Sign up for news of future CSaP events at: www.csap.cam.ac.uk/events/

£16M Boost for UK Robotics

Cambridge and Cranfield Universities are at the heart of a £16 million government initiative to boost the use of robotics in UK industry. The research project is a government-industry-academic partnership designed to develop smart machines that think for themselves.

DEMON, a novel unmanned air vehicle (UAV) is designed to be able to forego the use of conventional mechanical elevators and ailerons which usually control the movement of an aircraft in favour of novel aerodynamic control devices using blown jets of air

The research brief includes safe ways of monitoring in dangerous environments such as deep sea installations and nuclear power plants, 'nursebots' that assist patients in hospitals, and aerial vehicles that can monitor national borders or detect pollution. Universities and Science Minister, David Willetts, revealed that 22 exciting university-based research projects in the UK were being backed.

Led by the Engineering and Physical Sciences Research Council (EPSRC) and an eight-strong group of partners, the investment has over £4 million in support from industry itself.

This will include access to specialist laboratories, equipment, expertise and advice on commercialisation and industrialisation. The partners are BAE Systems, Schlumberger, National Nuclear Laboratory (NNL), Sellafield Ltd, Network Rail, SCISYS, DSTL and the UK Space Agency.

Robotics research and the development of intelligent autonomous systems, such as unmanned aircraft, are vital to many major UK companies, emerging industries, and SMEs, from advanced manufacturing to oil and gas exploration, nuclear energy to railways and automotive, healthcare to defence.

Autonomous and intelligent systems are capable of independent action in dynamic, unpredictable environments. They interact with each other and humans, using sensors to learn from their environment, adapting their behaviour and making choices based on their immediate and stored knowledge and experiences.

David Willetts said: "Robotics and autonomous intelligent systems are areas of science in which the UK has world class expertise, but to reap the full benefits for the economy and society we need to get better at applying the technology to industry. "This £16 million investment will bring together leaders from the research base and business to develop systems for a range of important sectors, from transport to aerospace. In addition, I have asked EPSRC, the Royal Academy of Engineering and the Technology Strategy Board to organise a roundtable to discuss the future of UK research in this area."

Cambridge University's input, led by Dr Carl Rasmussen and colleagues in the Department of Engineering, addresses 'autonomous behaviour and learning in an uncertain world.'

Cambridge's submission to the EPSRC says: "Our proposed framework will enable significant progress to be made in a large number of areas essential to intelligent autonomous systems.

"We aim to build on our expertise in Bayesian machine learning, multi-agent systems and control theory and by drawing together closely related developments in these complementary fields we will be able to make substantial improvements to the way artificial agents are able to learn and act, combine and select data sources intelligently, and integrate in robust ways into complex environments with multiple agents and humans in the loop."

"Robotics and autonomous intelligent systems are areas of science in which the UK has world class expertise, but to reap the full benefits for the economy and society we need to get better at applying the technology to industry."
David Willetts - Universities and Science Minister

Cranfield University is extending research in novel sensing, e-maintenance systems, and decision-making strategies. The integration of sensor-based information in geographically dispersed and less structured environments poses challenges in technology and cost justification which will be addressed for rail, aerospace and industrial applications.

Cranfield has already demonstrated its importance to this field of research. It helped develop DEMON, a novel unmanned air vehicle (UAV) which showcases a wide range of new technologies and has successfully demonstrated 'flapless flight.'

Growing bones with LEGO

A video produced for Google Science Fair shows how researchers at Cambridge making synthetic bone have turned to legendary children's toy LEGO For a helping hand.

Daniel Strange and Dr Michelle Oyen

Engineering isn't all glamour. In the course of devising and producing the stuff that improves all our lives, the lab often becomes home to laborious procedures that can start to sap the strength of even the hardiest engineers.

Researchers at the Department of Engineering developing synthetic bone have struck upon a novel way of getting round this – by using classic children's construction kit LEGO© – and their innovative use of mechanical toys in world-leading research has been featured in a new video produced by internet giant Google.

The video, which has already had almost 200,000 views, goes behind the scenes at the lab to show how the team develop the bone samples.

Bone has excellent mechanical properties for its weight, and synthetic bone has a range of revolutionary applications; from the obvious, such as medical implants, to the almost science fiction, such as a material in building construction. But the process involved in producing samples of bone is tedious and time consuming.

"To make the bone-like substance you take a sample, then you dip it into one beaker of calcium and protein, then rinse it in some water and dip in into another beaker of phosphate and protein – you have to do it over and over and over again to build up the compound," says Daniel Strange, one of the PhD students working on the research.

The team started to think about ways of automating the arduous process – the ideal being a robot of some kind that they could set up and run in the background. "One way would be to buy very expensive kit off the shelf," says Daniel. "But when we thought about it LEGO just seemed like the simplest, and cheapest, way to go about things." After a bit of investigation the researchers decided to build cranes from a LEGO Mindstorms robotics kit, which contains microprocessors, motors, and sensors that can be programmed to perform basic tasks on repeat. The sample is tied to string at the end of the crane which then dips it in the different solutions.

The team quickly discovered that the miniature machines made from the famous plastic blocks vastly reduced the human time cost of creating the bone samples: "the great thing about the robots is once you tell them what to do they can do it very precisely over and over again – so a day later I can come back and see a fully made sample," says Daniel.

Dr. Michelle Oyen, team leader and lecturer in the Department of Engineering, added: "Research is a funny thing because you might think that we order everything up from scientific catalogues – but actually a lot of the things we use around the lab are household items, things that we picked up at the local home goods store – so our LEGO robots just fit in with that mind-set."

Bone defects can result from trauma, infection and the removal of tumours, and beyond a certain size of trauma bone is unable to regenerate itself. Current treatments include bone grafts, which can be risky and greatly increase recovery time.

The team at Cambridge are working on hydroxyapatite–gelatin composites to create synthetic bone, and the work is generating considerable interest due to the low energy costs and improved similarity to the tissues they are intended to replace.

The video was made in the lab at the Department of Engineering by Google to help promote their online Science Fair, an international competition run by the company to encourage teenagers to engage with science.

"A lot of the things we use around the lab are household items – so our LEGO robots just fit in with that mind-set."
Dr. Michelle Oyen

For further information see research paper: Strange DGT and Oyen ML, Biomimetic Bone-Like Composites Fabricated Through an Automated Alternate Soaking Process, Acta Biomaterialia 7 (2011) 3586-94.

http://www.youtube.com/watch?v=WBEtUJmp05w

Royal Academy of Engineering elects four new Fellows from the Department of Engineering

Congratulations to David Cardwell, John Clarkson, Richard Penty and Malcolm Smith, all professors at the Department, who have been elected as Fellows of the Royal Academy of Engineering.

The Cambridge professors were among 59 new Fellows elected by the Royal Academy of Engineering at their AGM this week.
The RAE commended them as follows:

Professor David Cardwell, Professor of Superconducting Engineering and Deputy Head of Department: "David Cardwell has led the European effort in the development of bulk high temperature superconductors for high field engineering applications since 1998. His extensive research, which includes the publication of over 270 technical papers and patents, has produced the first generation of more powerful superconductors: unique, high quality single grain superconductors that exhibit record energy densities that can be manufactured by a novel practical process and are now being exploited commercially."

Professor P John Clarkson, Professor of Engineering Design and Director, Cambridge Engineering Design Centre: "John Clarkson is distinguished for his work in healthcare and inclusive design as well as on design process management and change management. A celebrated leader in the field, his books and papers, in addition to the centre that he directs, has major international impact. In a break from his academic career, he was Manager of the Advanced Process Group at PA Consulting Group, where he gained much practical experience of product development with a particular focus on medical equipment and high-integrity systems."

Professor Richard V Penty, Professor of Photonics: "Richard Penty's innovative work has led directly to products using photonics technology that have contributed to billion dollar markets. His first venture into the world of optical communications was via a student sponsorship with the National Coal Board where he designed a 1Mb/s optical line card. His current research interests include optical data communications, MMF systems (digital and analogue), high-speed optical communications systems, optical amplifiers, optical switching and routing, RF over fibre and short pulse, high power semiconductor lasers. He is a founder of Zinwave and PervasID."

Professor Malcolm C Smith, Professor and Head of Control Group: "Malcolm Smith has made key contributions to control theory, particularly robust stability, and in vehicle dynamics on the design of automotive suspensions. His current research includes passivity based control, circuit synthesis, mechanical networks, mathematical systems theory and automotive applications. Having studied initially at the University of Cambridge, he returned in 1990 as a Lecturer in the Department of Engineering, after experience as a Research Fellow at the German Aerospace Center, DLR, Oberpfaffenhofen, Germany; in the Department of Electrical Engineering at McGill University, Montreal; and as an Assistant Professor in the Department of Electrical Engineering at the Ohio State University."

Clockwise from top left: Professors David Cardwell, John Clarkson, Malcolm Smith and Richard Penty.

"We welcome our new Fellows: the collective expertise and vision of the best engineers is what drives our ambitious agenda and makes so many good things possible."
Sir John Parker GBE FREng,
President of the Royal Academy of Engineering

The Fellows, recognised to be amongst the UK's most accomplished engineers from industry, business and academia, were welcomed by Sir John Parker GBE FREng, President of the Royal Academy of Engineering. He said: "We welcome our new Fellows: the collective expertise and vision of the best engineers is what drives our ambitious agenda and makes so many good things possible. We are making progress in our aim to encourage a broader-based Fellowship that is more representative of the society we serve. But we cannot afford to be complacent and are continually reviewing our membership strategy to see how we might strengthen it."

Founded in 1976, The Royal Academy of Engineering promotes the engineering and technological welfare of the country. The Fellowship - comprising the UK's most eminent engineers - provides the leadership and expertise for their activities, which focus on the relationships between engineering, technology, and the quality of life.

Prize tomato

A group of students on the Department's MPhil course in Engineering for Sustainable Development have devised a project that will help Mexico's small producers of tomatoes by improving productivity and reducing wastage.

Tomatoes are big business in Mexico, especially in the centre and north of the country. Producers range from large growers, whose farms are equipped with extensive automation and irrigation systems, to small cultivators who eke out a living with the slimmest of resources on plots as small as a single hectare. Small growers are particularly vulnerable to technology lock-ins (barriers to switching to new technologies) and re-investment limitations. They do not have access to advice about improving productivity.

With these small growers in mind, a four-strong team of graduate students on the Department's MPhil course in Engineering for Sustainable Development devised The Ethical Tomato Company, a concept that has won them first prize in the McKinsey Innovate 2012 competition. Their £5,000 award, plus access to advice from McKinsey, will help them take their project on to the next stage and pilot their ideas in one of the major tomato-producing areas of Mexico.

The Ethical Tomato Company addresses two main problems: productivity and wastage. Team member Pedro Zaragoza explained: "Small farmers work with a very low level of technology which results in low productivity and low incomes. We propose to give them access to simple ways of improving their yields such as building timber-framed greenhouses and using organic compost that will enable them to improve their yields whilst protecting produce from pests and extreme weather."

"While in richer countries food wastage occurs chiefly at the consumer end of the market, as people buy more than they need and allow food to perish, in developing countries food wastage occurs lower down the supply chain. It is quite shocking to discover that for every tomato sold in Mexico, another one is wasted. This happens because tomatoes do not reach the market at the right moment. This high level of wastage, with the resultant loss of precious income, is another area in which we hope to be able to help," explained Jorge Garcia Moreno, also a member of the team.

"We plan to work with growers in bringing their produce to market and helping them to get a fair price. We propose to do this by becoming a tomato wholesaler and providing the logistics from farm to retail. The profits generated will be fairly distributed so that farmers get a better deal and let us expand the business to other farmers.

"Although Mexican farmers are highly skilled in growing salad vegetables, they do not always receive the right advice when it comes to using modern fertilisers and chemicals.

"It is quite shocking to discover that for every tomato sold in Mexico, another one is wasted."
Jorge Garcia Moreno

"Farmers have a lack of training in the use of nutrients such as nitrogen-based fertilizers. In order to achieve high yields they apply fertilizers and herbicides in excess and much of this runs off into the neighbouring water systems where it causes eutrophication. This is both wasteful and environmentally damaging. There are sustainable ways of improving yields that have minimal environmental impact," said Zaragoza.

"We plan to share the knowledge through workshops and work closely with them throughout the first planting cycle."

Both Pedro, who did his first degree in chemical engineering, and Garcia Moreno, who studied biomedical engineering, are Mexican nationals. Tomatoes are close to their culture and they claim Mexican tomatoes are some of the very best in the world, benefitting from sunshine and good soils.

One of the reasons that the team is planning to set up a pilot project in the centre of Mexico is that Pedro has family connections with the region's tomato growers. The other members of the winning team are Stephanie Hirmer, who is a civil engineer from Germany and Daniel Gallagher from Scotland, also a civil engineer. Stephanie has experience of working in Uganda whilst Daniel has experience of working in El Salvador.

Garcia said that the MPhil in Engineering for Sustainable Development has given him and his peers the tools needed to go out into the world and change things for the better. He said: "What's great about the course is that it encourages us to understand how social, environmental and economic aspects interact as part of a whole system, allowing us to develop holistic sustainable solutions."

The Ethical Tomato Company is now in the process of receiving advice from McKinsey consultants to develop plans for a pilot project in Mexico.

Further Information:
www.youtube.com/watch?v=TruWq647duY
www.innovate2012.mckinsey.com/
www-csd.eng.cam.ac.uk/

Contact:
Pedro Zaragoza
pedro.zaragozag@gmail.com
Centre for Sustainable Development
University of Cambridge, UK, CB2 1PZ
Tel: +44 (0) 7428835370

A safer route to a nuclear future?

By using thorium instead of uranium as fuel, nuclear power could be safer and more sustainable, according to new research.

ANDREA KIRBY

Since the development of nuclear power, many different strategies for the minimisation and disposal of nuclear waste have been considered.

There are two types of nuclear waste: Fission product waste and actinide waste. Fission product waste is generally easier to manage, because it has relatively short half-lives. By contrast, actinide waste has much longer half-lives; disposal strategies usually envisage that it will have to be stored in purpose-built facilities for thousands of years.

As a result, many researchers have begun to consider the actinides as a resource instead of a waste product, using the reactors themselves to recycle the actinide waste and then reuse it as nuclear fuel.

"The idea of taking actinide waste and getting rid of it in nuclear reactors rather than disposing of it in the ground is well-established, but this hasn't been thought possible using current commercial reactor technology," said Dr Geoff Parks, Senior Lecturer in Nuclear Engineering.

As well as the lack of suitable reactor technology, another issue with establishing an actinide recycling programme is the uranium which is used as fuel in nuclear power plants. The safety of nuclear reactors relies upon negative feedback coefficients, which stabilise the power level in the reactor if operating conditions change. What has been shown when recycling actinide waste in a uranium fuel cycle is that it can be recycled just once or twice before the recycled fuel develops a positive feedback coefficient, making it unsafe for use.

However, as one of Dr Parks' undergraduate students found, if uranium was replaced by thorium as a fuel source, current reactor technology could be used and the actinide waste could be safely recycled indefinitely.

"Our vision of how nuclear power might work in the future addresses quite a lot of the concerns about it such as very long-lived radioactive waste which is a burden on future generations."
Dr Geoff Parks

The idea of using thorium as a fuel source is not new; prototype reactors using thorium were operated in the United States in the 1960s. "The reason why thorium was never seriously pursued as an alternative to uranium is believed to be because the uranium fuel cycle generates much more plutonium, which is the raw material used for nuclear weapons," said Dr Parks. In addition to its greater resistance to proliferation than uranium, thorium is also about four times more abundant.

Ben Lindley, at the time a fourth-year undergraduate student, discovered that when recycling actinide waste in a thorium-based fuel cycle, the feedback coefficients stay negative, meaning that it can be continuously recycled, leaving only the much shorter-lived fission product waste to be disposed of.

Thorium could, in principle, be exploited immediately in existing nuclear reactors, but in order to maximise efficiency, Ben is looking at ways of reconfiguring the design of such reactors. Now in the first year of his PhD under the supervision of Dr Parks, Ben is working with Cambridge Enterprise to commercialise his research.

There are issues with using thorium, however. There is currently no thorium industry, so a great deal of infrastructure needs to be put in place before existing power plants can make the switch. However, in order to address the dual concerns of electricity supply for an exponentially growing population and global warming, a major investment needs to be made in nuclear power. While Dr Parks says nuclear is not the only part of the solution to those twin problems, it is a key component. With the advantages that thorium presents, and finite resources of uranium, thorium is now being seen as a viable alternative.

"The reasons for choosing thorium are its abundance in comparison to uranium, its greater proliferation resistance and the possibility of a fuel cycle where the only waste is fission product waste," said Dr Parks. "I think our vision of how nuclear power might work in the future addresses quite a lot of the concerns about it such as very long-lived radioactive waste which is a burden on future generations."

With the 50% increase in global population which is expected over the next 50 years, in order just to maintain per capita electricity consumption, a major power station would need to go online every day somewhere in the world. "The electricity-generating infrastructure to meet global energy demands is staggering when you think about it in those terms," said Dr Parks. "And if it's going to be low-carbon, then nuclear has to play a role in that."

Ski team test technique in wind tunnel

The Department's Markham wind tunnel played host to a number of British competitive skiers who came along to help in the development of a new piece of aerodynamic testing equipment.

British speed skier Tom Horn in the wind tunnel

Under the supervision of Professor Holger Babinsky, undergraduate James Richardson has spent the year working on a fourth year research project, 'The Aerodynamics of Speed Skiing'. One of the principal aims of the project is the design of a training tool to be used in the wind tunnel as a means to allow skiers to optimise their skiing posture and equipment by examining their aerodynamic drag in real time.

The project was initially proposed by Benja Hedley, an alumnus of the Department, and a member of the British speed skiing team. The overall aims of the project were twofold: the first was to investigate the various factors that affect the aerodynamic drag of a skier, and so try to minimise the drag. The second was to design and construct a training rig which would allow skiers to see their aerodynamic drag in real time while in the tunnel in order for them to reduce their drag as much as possible through trial and error. This second aim was achieved during the course of the year (with the assistance of Benja Hedley as an evaluator), through a set of skis attached to a force-measurement device, and a computer monitor attached to the tunnel floor between the skis.

With the rig complete, a number of skiers were invited to the Department in order to test out the new equipment, including Ed Drake, the UK's number one alpine skier, Tom Horn, the holder of the British SDH (Standard Downhill) speed ski record, and several members of the British junior ski team. The reaction to the rig was overwhelmingly positive, with all the skiers feeling that they had benefitted from their time in the tunnel, and from a new-found appreciation of their aerodynamics.

Tom Horn commented after his first couple of runs in the tunnel: "I've learnt more about speed skiing in the last five minutes than I have in five years of speed skiing!"

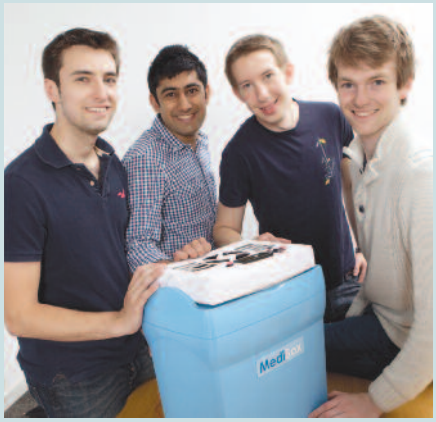
The research is continuing under Robert Sills and Professor Babinsky.

"I've learnt more about speed skiing in the last five minutes than I have in five years of speed skiing."
Tom Horn, British speed ski record-holder

New manufacturing innovations

Eleven innovative design projects were on display at the Department's Institute for Manufacturing to mark the end of a year-long project.

Rotary Cone
Pippa Horton, Arron Rodrigues, Robin Šmíd



MediBox
Ed West, Simon Holroyd, Sidharth Khandelwal, Elliott Dobson

Pegasus Polo Boot
Karin Bergvall, John Ginger, Lukas Wong

Unlayered
Logan Bishop, Mason Edwards, Charlie Hughes, Wai-chuen Cheung

The Design Show is part of the Manufacturing Engineering Tripos (MET) course, a programme for 3rd and 4th-year engineering students who have successfully completed the first two years of an engineering degree.

The aim of the design project is to develop a new product with real business potential. Each team must work together to identify a customer need, research the market, develop an original design concept and create a full business plan.

The Design Show is held each year for an invited audience of local industrialists and designers. Students put together displays to explain the technical and business ideas behind the products, together with design details and prototype models of the products themselves.

One of the products on display has already been recognised by industry as a potential solution to a complicated and expensive problem. The **Rotary Cone** is a new approach to the removal of lumps for the food processing industry. With its simple cone-in-cone mechanism, it allows the rotating inner cone to crush and compress the lumps as they flow through, providing a safer, cheaper and more hygienic powder-lump prevention. The engineering students have been working closely with Peterborough based Olympus Automation, to provide a viable solution for this problem. A prototype is currently being manufactured for trial at the plant with the view to incorporating the Rotary Cone into their food processing chain. The picture below shows the students, Pippa Horton, Arron Rodrigues and Robin Šmíd, with their prototype design.

Harry Norman, Managing Director of Olympus Automation said, "As part of Olympus Automation's commitment to working positively with the local community we were delighted to be approached by Pippa, Arron and Robin. Olympus Automation discussed various projects and together we decided to collaborate on powder-lump prevention as it presented a real challenge to the industry. Existing technology used aggressive, dangerous equipment that required extensive guarding with little flexibility to change minimum lump size. The Cambridge team created and developed a novel solution to the problem; Olympus Automation believe that this can be refined and taken forward into commercial applications. Throughout the process the Cambridge team have been professional, innovative & great ambassadors of the University".

Another of the engineering teams have developed **Medibox**, a solution for the transportation and monitoring of temperature sensitive medical substances. Ed West and Elliot Dobson, two of the product designers explain the key benefits, "MediBox allows the safe, reliable and efficient transportation of temperature sensitive medical substances designed to solve real problems experienced in the field. A wide range of

Pulse
James Lobo, Helen Hoogewerf-McComb, Lawrence Baynham

Soteria
Helen Dean, David Hotchkiss, Sam Massey

unveiled at student Design Show

medical substances, including vaccines and blood samples, require careful temperature control during transportation and storage. In the case of vaccines, regulations state that they must be discarded if they fall outside a 2 to 8°C temperature window." Sidharth Khandelwal, fellow team member, explains the key features, "With the Peltier elements and the in-situ thermometer, the temperature of the contents is precisely maintained and recorded, while warning systems alert the user to potential deviations".

Karin Bergvall, John Gingerand and Lukas Wong have developed a hi-tech leg protection system for polo ponies, the **Pegasus Polo Boot**. Karin explains, "Polo is a physically demanding game for both rider and pony alike.

Unfortunately injuries to the ponies do occur but this product aims to reduce the risk of injuries, whilst also maintaining a comfortable environment for the ponies' legs".

Whilst current products on the market make use of bandage wraps combined with hard shell tendon boots, or neoprene wrap-around solutions, neither is optimised for performance or protection. The Pegasus Polo Boot uses a combination of hi-tech materials and technologies in order to provide superior impact resistance, cooling features, moisture control and ease of cleaning. Novel technologies such as hydrophobic coatings, phase change materials and high impact materials have been incorporated to bring the product into the modern age.

Other products on display at the Design Show were:

- **Unlayered** – a revolutionary 3D printing technology that exploits submerged material consolidation for a rapid and novel manufacturing process.
- **Pulse** – a headphone type device that enables deaf users to perceive sounds and their directions in unfamiliar environments.
- **Soteria** – a device to protect motorcyclists from injuries caused by excessive head movement during collisions.
- **Refleks** – a solution to reduce the impact of potholes by forewarning motorists.
- **The Ablus Equip** – a device for manual wheelchairs to promote independence and improve safety on gradients.
- **WHB Acoustic C3** – high-end headphones that unfold to become a pair of portable speakers.
- **Hefti** – a beekeeping aid to monitor the hive weight enhancing the chance of bee survival in the winter.
- **Ectotherm** – a device that enables skiers to vary the insulation properties of their jacket.

Ectotherm
Chris Ashby, Beth Keith, Joel Chong

Hefti
Dan Ayres, Poppy Brewer, Fiona Gillanders, Jenk Kilich

Refleks
Nick Schweitzer, Justine Shek and Bryan Sin

The Ablus Equip
James Evans, Richard Totten, Edward West

WHB Acoustic C3
Will Benjamin, Matt Hall, Simon Wolf

Call of the wired

For generations, we have dreamed of machines with artificial intelligence with which we can have real conversations but, despite amazing technological advances, such devices seem some way off. Now researchers at Cambridge are changing the picture, by remodelling the essence of spoken dialogue systems.

Oscillogram

: BRECHTJE POST

Following the death of Steve Jobs, one of many videos which started to circulate widely on the internet showed the Apple Co-founder at a watershed moment, launching the very first Macintosh in 1984. After demonstrating the machine's facility for word processing, design and even animation, the climax came when Macintosh literally announced itself to the world, talking to an amazed audience with synthetic speech before handing back to Jobs and announcing that it was going to "sit back and listen". A beaming Jobs received a five-minute ovation.

How far we seem to have travelled. Modern smartphones are pocket computers that talk to us using speech recognition software, and owners of an Apple iPhone 4S can ask their device about the weather, or tell it to text a friend. Unlike the early Macintosh, this is no slick gimmick using pre-programmed speech on a floppy disk. Machines can listen to us, interpret our words, and respond.

Yet in a sense we have also come less distance than we hoped. An historian of science might argue that the self-aware illusion of intelligent speech that Jobs created back in 1984 met with euphoria because of a vision that is more science fiction than fact. Computing pioneers in the mid-to-late 20th century imagined conversations with far more sophisticated artificial intelligence in the future. They dreamed less of the iPhone 4S, more of HAL from 2001: A Space Odyssey.

This type of interface remains a distant prospect. Siri, the speech recognition software used in the iPhone, is a system we talk to, but not one with which we converse. Achieving that remains a complex mathematical challenge and usually throws up new problems with every breakthrough achieved. In this demanding field, researchers at Cambridge have traditionally been leaders. Today, the University's Dialogue Systems Group, in the Department of Engineering, are making more advances than most.

"Siri is a sort of personal assistant," Professor Steve Young, who leads the group, said. "If you ask it a question, it comes back with an answer, but after that you more or less have to start again. We want to develop systems with which you can have a proper conversation."

Such devices are likely to become more necessary over time. The amount of information on the internet is rapidly growing and, before long, it will take more than question-answer interfaces to cut through it. We need systems that are attuned to our needs - in short, we need computers that discuss things.

Professor Young's group, along with an international team of collaborators, is developing one such spoken dialogue system (or SDS), in a European Union (EU) project called PARLANCE. As with some of their earlier work, this is a project which involves statistically modelling a system that talks to humans and learns as it goes. Fundamentally, the idea is not dissimilar to teaching a child new vocabulary, and the shifting set of ideas the words may represent.

Made marketable, PARLANCE would be far more three-dimensional than current systems. Where an existing SDS can, for instance, help house-hunters find properties for sale in a given town, PARLANCE would be able to process a request for a three-bedroomed house, with two bathrooms, near a good school and within walking distance of the local supermarket. Users would be able to ask it for one of these attributes, then add more to refine their results. Creating this, however, requires a reconception of how such systems work. A 'cognitive' SDS like PARLANCE has to be able to model uncertainty, or cope with the fact that humans rarely mean exactly what they say. No current SDS is able to handle this, because their modelling is too simple. In existing systems, speech is converted into data, then given to a 'dialogue manager', which tests the data's assorted attributes against an internal database of pre-programmed information, looking for what it thinks is an appropriate response.

"All the systems out there do this on the basis of pre-written programmes," Professor Young explained. "Essentially, the developer programmes the system with a flow chart of possible conversation routes. This is very labour-intensive, and also very fragile. The user can very easily end up in the wrong bit of the flow chart altogether."

PARLANCE is different because, unlike a typical SDS, it refines its responses with experience. Critically, it takes into account not just the last thing its user said, but its overall assumptions about their intentions, their earlier questions, and its experiences from previous conversations. This combined knowledge is merged into a 'belief state' – the system's overall, shifting grasp of what is going on.

Underlying this is an approach called reinforcement learning. The system's decision processes are continually refined depending on whether it receives positive or negative feedback from users. A high score, for a correct response that gives the user exactly what they need, or a negative score, for useless information, allows it to refine its future behaviour.

In 2008, Professor Young's team launched CamInfo, an SDS that people could telephone to ask about local restaurants, and which was developed in an EU project named CLASSiC. A 2009 demo on YouTube shows the system responding to a caller asking for a Chinese restaurant in a town's main square. There is no Chinese locally, but when the caller then says "What about an Italian restaurant?", the system retains details from earlier in the conversation, and finds an Italian in the same place.

Now PARLANCE aims to progress this by helping users with multiple goals. As with the house-hunting example, it will try to cut through swathes of information online and cope with multiple types of requests in one conversation, rather than a single enquiry about a restaurant.

Professor Young and his team are also developing various new features. These include 'hyperlocal search', which allows the

system to focus the conversation on the amenities in the local neighbourhood. The system is also being developed to use and respond to back-channel signals. These are the murmurs and grunts of agreement or disagreement such as "hu-huh" and "hmmm" that humans use unconsciously in natural dialogue to orchestrate the turn-taking and flow of information.

But do we really need this stuff? After all, it often seems that nothing can replace real human interaction. Professor Young agrees, but points out that the increasing investment in speech technology by major corporations such as Apple, Google and Microsoft clearly shows that we are heading towards a world of speech interaction with our computers.

"We want to develop systems with which you can have a proper conversation."
Professor Steve Young

Nor is this simply a story about the unstoppable rise of the machines. In fact, it may become one about the empowerment of the Luddites. "Speech is one of the most inclusive media we have," Professor Young observed. "Potentially, speech-controlled systems will enable us to bridge the generation gap in computing. We need to get away from crude systems that require users to constantly learn to push different combinations of buttons, which presents real barriers to some sections of the population such as the elderly. Speech will make complex systems accessible to virtually everybody."

Fluent dialogue systems that can cope with the most subtle aspects of human expression remain some way off – and perhaps we will never be able to chat with computers like our science fiction alter egos. Yet projects such as CLASSiC and PARLANCE are not only incrementally taking us closer to the goal of truly cognitive systems, but they are also changing the playing field by altering the basis on which it will be done. The SDS in your phone requires the pre-existing calculation of a programmer, but future systems will adapt on the basis of the conversations they have with you. Socrates once said that the only true wisdom is in knowing you know nothing. Perhaps the same is now becoming true for machines.

Professor Florin Udrea wins Royal Academy of Engineering award

Professor Florin Udrea has won a Royal Academy of Engineering Silver Medal award for his outstanding commercial success. Florin received his medal at the Academy's annual awards dinner at London's Royal Opera House on 26 June.

"Our Silver Medallists represent the very best of entrepreneurial British engineering right across the whole spectrum of engineering. From semiconductors, communications and the web, right through to bridges, engineering innovation is contributing more and more to our lives and our workplaces."
Dervilla Mitchell FREng, Chair of the Academy's Awards committee

The Royal Academy of Engineering celebrates the strength and diversity of UK engineering with the presentation of its coveted Silver Medal to outstanding British engineers working in the fields of data, construction, telecommunications and electronics. The Silver Medal winners have achieved significant commercial success in their fields and are recognised for advancing the cause of engineering in this country.

Florin is both an academic and an incredibly successful entrepreneur, he leads the High Voltage Microelectronics group at the Department of Engineering whilst being the founder of two of the University's most successful start-ups: Cambridge Semiconductor Ltd (Camsemi) and Cambridge CMOS Sensors Ltd (CMOSS). Camsemi is a pioneer in the world of semiconductors, developing and patenting more energy efficient chips. To date they are generating multi-million pound revenue and have 70 employees in offices in the UK, Taiwan, China, Hong Kong and the US.

Florin is also co-founder and CEO of CMOSS, a company developing revolutionary technology for environmental monitoring. Its miniature gas sensors for CO2 and methane detection are set to replace the expensive, bulky equipment the industry currently uses. At present the company has 15 world-wide customers and a potential growth forecast of £10 million a year.

Infrastructure revolution

Technology has advanced to the point where the condition of bridges, tunnels and buildings can be monitored in unprecedented detail. Now a new Centre at Cambridge has been formed to kick-start the smart infrastructure revolution.

London Bridge, so far as we know, is not falling down. Whether we would be able to tell if it was about to, however, is a different question. And, if it was, we would need to calculate how much time it had left, so that we could establish when to deny people and traffic access for their own safety. Such matters have been preoccupying researchers like Professors Robert Mair and Kenichi Soga for most of their careers – and with good reason.

Next to many icons of British infrastructure, London Bridge (39 years old in its present incarnation) is a mere spring chicken. Every day, millions of us use bridges, tunnels and pipelines constructed in the Victorian age. Our cities and towns are densely populated networks of infrastructure, much of it a century old or more. They are shaped by the clash of political and public expectations, but they are also home to some of the most important listed buildings, structures and heritage sites in the world. Given the scale of the job involved in ensuring that Britain's infrastructure remains standing, it seems both astonishing and oddly reassuring that most of it does.

Horror stories about what could happen if it all went wrong sometimes crop up in the news. In 2007, the I-35W Mississippi River Bridge near Minneapolis fell down during the evening rush hour. Thirteen people were killed and more than 100 were injured. This tragedy, it later emerged, was a direct result of the fact that those responsible for maintaining the bridge simply did not know enough about its condition to predict and prevent the collapse.

Yet such ignorance is fast becoming a thing of the past. Thanks to rapid advances in technologies like wireless sensors and fibre optics, it is now possible to keep both old and new infrastructure under constant surveillance, monitoring strain, temperature, displacement, humidity or even a crack in a wall. Researchers believe we are on the verge of developing 'smart infrastructure', which will allow buildings, tunnels, bridges, sea defences, or road and railway cuttings to be subjected to regular health checks at the touch of a button.

Robert Mair and Kenichi Soga, both Professors of Civil Engineering, are among a group of academics at the University making that vision a reality. Last year, an Innovation Knowledge Centre (IKC) for Smart Infrastructure and Construction was set up, based in the Department of Engineering, but involving colleagues from across the University – in the Department of Architecture, the Computer Laboratory and Judge Business School. The IKC works with construction, infrastructure and technology firms. Its aim is ambitious: its founders believe that it could kick-start a new industry dedicated to smart infrastructure and construction in the UK.

A circular shaft in East London with optical fibres embedded in diophragm wall panels

NJEMILE FAUSTIN

"London Underground needs to know if the Northern Line is good for another 20 years, or another 80, or longer. At the moment, nobody really knows."
Professor Robert Mair

"The analogy I use when describing our IKC is that of a car," Professor Mair said. "A modern car has sensors that can tell you such things as when the brake lights have failed, or the fan belt is broken. Smart monitoring can give us equivalent information about buildings, bridges and tunnels as well."

In spite of their huge potential, the latest sensor technologies are not routinely used in infrastructure at the moment. The Forth Road Bridge, where corrosion in the main cables has been monitored since 2003, is a rare exception. Professors Mair and Soga believe that we have barely begun to exploit the potential of the latest technologies; little is done to monitor how most bridges are performing and there is virtually no such monitoring of buildings.

Alongside the priority of public safety, there is a strong business case for constantly scrutinising infrastructure. Worldwide, its maintenance costs billions of dollars every year. Even a small percentage improvement in efficiency would engender major savings. "London Underground needs to know if the Northern Line is good for another 20 years, or another 80, or longer," Professor Mair said. "At the moment, nobody really knows."

Sensors and optical fibres

One of the aims of the IKC is to develop a new generation of wireless sensors to the point of marketability by 2016. These small devices measure a structure's physical conditions, such as temperature, vibration and strain. They are ideal for monitoring those parts of infrastructure that cannot be reached with ease, like inside a tunnel or under a suspension bridge.

The Engineering Department has already conducted trials with such technology, including one that monitored humidity in the anchorage chambers of the Humber Bridge, where the steel anchor cables have to remain relatively dry to avoid corrosion. Wireless sensors have also been installed to monitor a tunnel on the London Underground, where they measure changes in inclination and cracks.

With wired sensors now a thing of the past, the 'Holy Grail', as Professor Mair puts it, is removing the need for batteries. At the moment, the sensors need to have their batteries replaced. One of the IKC's projects will look instead at using micro-electrical mechanical systems (MEMS), in which miniature devices and circuitry can be etched on to a silicon chip as part of the sensor. Potentially, a very small turbine could be included to harness the wind power produced by passing trains in the tunnel, making the system entirely self-sufficient. On bridges, similar technology could utilise the vibrations from vehicles.

Optical-fibre monitoring, another key research focus for the IKC, has similarly huge potential. Recently, when a new tunnel was built beneath the century-old Thameslink tunnel in London, Cambridge engineers installed optical fibres around the inside of the old brick tunnel. These produced continuous measurement of the changing strains and temperature at every single point along the fibre. Previously, engineers would have had to use conventional survey techniques to analyse the impact of the new tunnel. Now, optical fibres can be used to measure strain directly and continuously – usually at a cost of just 10 pence a metre.

In 1994, Professor Mair headed the geotechnical group examining the impact of London's Jubilee Line Extension on the stability of that greatest of British landmarks, Big Ben. Then, huge amounts of meticulous manual measurement went into assessing whether the clock tower was under threat. When boring begins for the huge Crossrail project underneath London, he and his team will again be analysing the impact on other buildings, but this time also with fibre optics and sensors. "The technology we have now offers a whole new dimension compared to what was available for the Jubilee Line Extension," he reflected.

In new structures, incorporating optical fibres during the construction process itself would enable an unprecedented level of 'cradle to grave' analysis of how stable our infrastructure is. At the moment, considerable over-estimation goes into the use of many components in buildings and structures to guarantee safety. Better monitoring would allow construction firms to make far more accurate judgements about how much material to use. With technology also enabling the off-site manufacture of building components, it should be easier for these firms to insert sensors and optical fibres into walls, facades and beams, by adding them to components in the factory before they reach the building site – thereby creating the 'smart' building.

Smart infrastructure

The IKC has been funded to the tune of £17 million, £10 million from the Engineering and Physical Sciences Research Council and the Technology Strategy Board, and the rest from industry collaborators. By 2016, Professors Mair and Soga hope that the Centre will have advanced both the technology and business cases sufficiently to be able to support its future through industry collaboration alone.

If all goes to plan, Britain could by then be well on its way to becoming a centre for smart infrastructure and construction on a global scale. Work is already taking place with partners in the USA, China, Hong Kong and Japan, parts of the world where monitoring infrastructure is vital given the greater threat of earthquakes and other natural disasters. Professors Mair and Soga have already used optical fibres successfully in a project on the Singapore metro. "The infrastructure of some of these countries is in a state of very fast growth," Professor Soga added. "Like us, they are starting to realise that smart monitoring could have huge benefits."

Escape from Colditz

Colditz Castle, one of the most notorious prisoner of war camps in Nazi Germany, was supposed to be escape-proof. But in the dark days at the end of World War II, a group of British officers dreamt up the most audacious escape plan in history.

In a secret workshop in an attic in the castle they constructed a two-man glider out of bed sheets and floorboards. They were going to fly to freedom from the roof of the castle, but the war ended before they could put their plan into action, so no one knows if it would have worked.

Now the Brits return to Colditz to finish the job for a Channel 4 TV documentary. Dr Hugh Hunt, of the Department of Engineering, leads a crack team of aeronautics engineers and carpenters to rebuild the glider in the same attic using the same materials. Then he attempts to do something the prisoners never got a chance to try: use a bathtub full of concrete to catapult the glider off the roof of the castle.

This 90-minute film is about the most audacious plan ever devised to escape from a prison camp. In 1945, two British prisoners-of-war were to be catapulted from the roof of notorious Colditz Castle in a homemade glider, fly it to a meadow 180 metres below, where they would continue their escape on foot. The "Colditz Cock", as the glider was called, represents an incredible feat of aeronautical engineering – particularly since it had to be built in secret in a tiny attic using homemade tools and improvised materials like bed boards, sleeping bags, gramophone springs and porridge!

Unfortunately, the war ended before the Cock ever had the chance to stretch its wings and no one knows if the crazy idea would have actually worked...until now. Led by Hugh (also seen in Dambusters: Building the Bouncing Bomb and Digging the Great Escape), a team of daredevil engineers attempt to rebuild the glider in the very same loft in Colditz, using similar materials to the wartime POWs and comparable homemade tools. Luckily, our modern day escapers are able to follow in the footsteps of their intrepid forebears. Quite a bit is already known about the glider and how it was built; there are the original plans and there is even a snapshot of it.

However, once they've finished building the plane, the team will take an almighty leap into the unknown. Precious little information remains about how the Colditz Cock was to be launched from the roof. Officials from the State of Saxony who own the castle granted Windfall Films permission to restage the glider launch from the roof of Colditz to find out whether the plan would have ever actually worked. Somehow, the team have to construct a runway 20 metres above ground on the apex of a roof, and contrive a launching mechanism which will dispatch their glider efficiently and silently into the air. It's hardly surprising the feat has never been attempted before.

Hugh goes behind the legend, and finds out what it was really like for the men imprisoned here, and the families waiting for them back home. Along the way, archeologists open up some of the castle's other famous escape routes.

CHANNEL 4

Glider over the town of Colditz

Hugh Hunt has a compelling personal reason for taking part in the project. His beloved uncle William "Andy" Anderson was imprisoned in the castle from 1941–1945. Andy, a celebrated Colditz face, was a leading forger, running a secret production line that conjured up convincing German documents for would-be escapers. Hugh knows very little about his uncle's time in Colditz, and the film follows him as he learns about Andy Anderson's inventive genius in the face of adversity, and challenges Hugh to recreate some of his uncle's wartime improvisations.

'Escape from Colditz' can be seen on 4oD.

http://www.channel4.com/programmes/escape-from-colditz/4od

Where are they now?

2012 saw graduates of the MPhil course in Engineering for Sustainable Development (ESD) come back to the Department of Engineering from all over the world to celebrate the programme's tenth anniversary and catch up on developments.

When a fatal earthquake hit the city of Christchurch in New Zealand in February 2011, the most severe in a series of catastrophic events, Kristen MacAskill was the other side of the world studying for an MPhil in Engineering for Sustainable Development (ESD) at Cambridge University. Woken by a text from a friend, she spent the early hours of the morning on the internet following news updates. As a New Zealander, her immediate thoughts were for the safety of her family and friends back at home – and she was relieved to get a phone call from her mother who had been stuck in a high-rise building in the centre of the city.

Today Kristen is working as an engineer for the "Stronger Christchurch Infrastructure Rebuild Team", a group dedicated to rebuilding the 'horizontal' infrastructure of a devastated city, covering roads, waste water management, water supply and storm-water services. "Our team comprises people from a range of organisations delivering vital work that will cost in the order of $NZ2 billion," she says. "Witnessing the deconstruction of the central business district is emotional, but it also presents Christchurch with huge opportunities to implement changes and shape a world-class city. For me, the experience of playing a part in this critical work is tremendously rewarding."

When more than 170 engineers gathered in Cambridge last month to celebrate the tenth anniversary of the University's MPhil course in Engineering for Sustainable Development (ESD), Kristen, who was in the ESD class of 2010-2011, was among them. She was keen to meet up with old friends, meet movers and shakers in the world of sustainable engineering, and get up to speed with new developments and talking points in the field.

Like most ESD students Kristen had a good chunk of industry experience behind her before she embarked on the MPhil. After graduating from Canterbury University, Christchurch, where she took an undergraduate degree in Civil Engineering followed by a Masters in Engineering Management, Kristen had worked in Australia in the transport group of a global engineering consulting company. She says: "I decided to take Cambridge's ESD course because I wanted to develop a better understanding of how to implement sustainability concepts within engineering and business. Sustainability is difficult to define as an end goal, but the course gave me insight into expanding thinking using a sustainability philosophy – a process which will ultimately support better development outcomes."

The ESD MPhil was set up in 2002 by the Engineering Department with support from the Cambridge-MIT Institute in order to introduce concepts of sustainability and explore the context in which engineering sustainability must take place. Each year it recruits around 35 to 40 students and a total of nearly 300 engineers have graduated from the programme over its ten-year history. The students come from all over the world. The latest cohort included participants from Europe, Nigeria, Latin America, South America, China and Australia.

KRISTEN MACASKILL

Kristen MacAskill at work in Christchurch, New Zealand?

"Witnessing the deconstruction of the central business district is emotional, but also presents Christchurch with huge opportunities to shape a world-class city."
Kristen MacAskill, graduate of the Engineering for Sustainable Development programme

Developed in close collaboration with expertise drawn from industry as well as from MIT, the course is designed for students from an engineering background. The programme recognises that engineers operate within an increasing set of constraints and deal with an ever-widening range of challenges. It identifies key aspects that are needed when approaching engineering problems from a sustainability perspective and indicates the methods and approaches used to develop the skills required.

To engage students in a broad range of activities, the course is divided into three components. All students take a core programme which delivers tools and understanding to complement the technical background of participants. Similarly, all students engage with Management of Technology and Innovation taught by Cambridge Judge Business School. They also chose four elective modules from a list of topics offered by the Centre for Sustainable Development, the Engineering Department and other Departments within the University. The final component is a dissertation which often involves working with companies, government agencies and other organisations.

Jason Porter (who took the ESD MPhil in 2007-2008) is now a senior engineer working for Aboriginal Affairs and Northern Development in Canada. He explains: "Many First Nations communities in Canada are similar to developing countries and have a much lower standard of living than typical Canadian communities. I provide engineering support to a group of these communities to help them develop close drinking water systems as well as better housing and schools. Sustainable thinking is essential in this work as there are significant social and environmental issues and we have limited financial resources."

For Jason, who took his undergraduate degree (Mining Engineering) at Queen's University in Ontario, the value of the ESD course lay in its exploration of the complex challenges that engineers and others face in terms of working towards sustainable solutions. "The programme didn't alter my basic philosophy but showed that you don't always need a well-defined solution to make progress," he remarks. "On a personal level, the most demanding aspect of the course was finding a balance between keeping up with the course work, spending time learning from fellow students, and enjoying all that Cambridge has to offer."

Just over a third of the students who take the ESD course are from developing countries and many of those who come from developed countries go on to work overseas in development projects. Sinomnqa (Nomi) Bodlani (who also did the course in 2007-2008) works in Johannesburg as a senior analyst with Davies Consulting Associates. Much of her work is for mining companies whose activities have significant social and environmental impact on the communities and environment where they are located. Her day-to-day work involves identifying and implementing improvement opportunities at all levels of the business ranging from business support processes to environmental management and operational processes. This entails developing an understanding of a wide range of issues within an overriding business strategy as well as actual operating realities.

Nomi did her first degree in mechanical engineering at the University of Cape Town followed by a research post looking at the

energy absorption and crash characteristics of steel materials. Nomi was a Mandela Magdalene Scholar (a Commonwealth Scholarship) at Magdalene College, Cambridge, and this enabled her to take the ESD course. "I had not been exposed to the concept of sustainability before and quickly understood that everything has sustainability implications. Now I approach anything I'm doing with the question: what does this mean from a sustainability point of view?" she says. "Coming from South Africa, a particular challenge was contextualising sustainability as identified in the first world to the developing world. An aspect of the course useful for my personal development was reflecting and sharing during group work which involved translating our experiences to something that others could learn from."

James Dodds (another member of the class of 2007-2008) is a British national who spends much of his time working overseas as a renewable energy technical consultant for Mott MacDonald. He has recently been working in South Africa assisting the Government to procure several gigawatts of renewable energy generation: a programme that has been heralded by the World Bank as a leading example of a clean energy project in a developing country. "Cambridge's MPhil in ESD is designed so that you learn through the experience of others. You're encouraged to ask tricky questions and think independently. One of the best things about the course is its links with industry: you are hearing first-hand from leading industry professionals who come to give lectures and answer questions. I learnt more in one year at Cambridge than I have during five years of working in the industry," he says.

"What the course made me realise is the vast scope that exists for better sustainability and the dire consequences of continuing with business as usual. Where people are in embedded positions, there is often no easy way to introduce sustainable ways of working – but people aren't daft and if you get them to ask the right questions and look on longer timescales then they will bring about their own changes."

At the end of their year in Cambridge, each cohort of ESD students presents summaries of the dissertations written as part of the course. Topics tackled by the class of 2012 provide a glimpse of the scope and reach of projects undertaken: they range from a study of sustainable management of waste water in Nigeria to an exploration of the use of bamboo as an alternative construction material in Ecuador, and from an analysis of incentives for green commercial building development in Hong Kong to research into sustainable energy for Ireland.

Engineering for Sustainable Development
www-csd.eng.cam.ac.uk/

Collaborative research centre announced

The University of Cambridge and the King Abdulaziz City for Science and Technology (KACST), Riyadh, have announced the formation of a collaborative research centre based in Cambridge.

From left, Professor Soliman H. Alkhowaiter (Consultant, KACST) Professor Ibrahim S Al-Mssallem (Centre Co-Director, KACST), His Highness Dr Turki S AlSaud (Vice-President, KACST), Professor Sir Leszek Borysiewicz (Cambridge Vice-Chancellor), Professor David Cardwell (Centre Co-Director, Cambridge), Professor Ann Dowling (Head of Department of Engineering), Dr Jennifer Barnes (Pro Vice-Chancellor for International Strategy).

The centre will form the platform for cooperation in scientific research, the transfer of technology and the training of postgraduate students and post-docs within the two institutions.

The centre, which has been funded by KACST, will focus primarily on research and emerging technologies relevant to long-term Saudi development strategy. The initial three-year phase of the centre will target the four key research areas of biotechnology for high valued healthcare products, bulk superconductors for flywheel energy storage and other high field applications, inkjet research and the development of oxide materials for commercial LED and photovoltaic technologies. The centre will include three University Departments (Engineering, Physics and Chemical Engineering and Biotechnology) and will be directed by Professor David Cardwell (Department of Engineering) and Professor Ibrahim S Al-Mssallem (KACST).

It is anticipated that funding for the centre will be extended by up to ten years on completion of the initial phase, and that it will be expanded to include up to a further six areas of research after the first annual review.

The formal agreement for the centre was signed by His Highness Prince Dr Turki bin Saud bin Mohammed AlSaud, Vice President of KACST, and the Cambridge University Vice-Chancellor in November, 2011.

Ancient Egyptian mummy saved by engineering and LEGO

Thanks to an ambitious conservation project and some tiny pieces of plastic, the ancient Egyptian mummy case of Hor is now on display in the Fitzwilliam Museum, Cambridge.

The conservation of the cartonnage mummy case was undertaken with the assistance of the Department of Engineering, who helped construct clever frames to support the delicate case during conservation and a new display case with internal supports using LEGO©.

The mummy case was found in the Ramesseum at Thebes in 1896. The gilded wooden face had been torn out by robbers and the mummy removed. Cartonnage is a uniquely Egyptian material, often only a few millimetres thick, consisting of layers of plaster, linen and glue. It is remarkably rigid but also very sensitive to humidity. At some point Hor had been exposed to damp conditions and had sagged dramatically around the chest and face. This caused structural problems and also serious cracking and instability in the painted decoration. There had been some attempts at repair and restoration, most probably in the cartonnage's early years in the Museum.

In the recent project, the conservators wanted to reshape the cartonnage by using humidity to soften it and allow it to be manipulated. But introducing water into this material was risky because the painted surface is very easily damaged by moisture, and furthermore, if the whole cartonnage were softened at once there was a real danger it would collapse. Introducing water in a controlled way to the distorted area could only really be done if the cartonnage was face-down – but the fragile state of the chest and face made this almost impossible.

Luckily, help was available from the Department of Engineering. In the latest of a series of collaborations with the Museum's conservators, the Department offered the problem as a project for a final year student. The challenge was taken up by David Knowles. In close consultation with the Fitzwilliam, David devised and made a frame to suspend Hor face-down while the reshaping was carried out. Using a combination of traditional wooden frames and mouldable materials designed for medical use, Hor could be completely supported for weeks at a time, allowing conservator Sophie Rowe to reshape the cartonnage very gradually.

Once Sophie had successfully reshaped the chest and face and stabilised the surface, David designed and built a display mount for the mummy case. An essential part of this is the internal support which ensures that the structure cannot collapse again in the future. Six light, ingenious little structures made from LEGO have been placed inside the chest cavity. They are adjustable using screw threads, and are padded with archival foam where they are in contact with the ancient surface.

THE FITZWILLIAM MUSEUM, CAMBRIDGE

David Knowles, Sophie Rowe and Andor Vince positioning the cartonnage in the purpose-built frame

A great result for Hor, who can now be displayed safely and for David, who was awarded a prize by the Department for his final presentation on the project.

Professor Bolton gives 52nd Rankine Lecture

Professor Malcolm Bolton, Head of the Geotechnical and Environmental Group, delivered the 52nd Rankine Lecture at Imperial College on "Performance-based design in geotechnical engineering."

The lecture was introduced by Professor Bolton's Department colleague Professor Robert Mair who described him as "a distinguished engineer who has had a major influence on research in so many areas of geotechnical engineering." Professor Bolton, who is Professor of Soil Mechanics and Director of the Schofield Centre for Geotechnical and Construction Modelling, was elected a Fellow of the Royal Academy of Engineering in 2008.

The concept of his lecture was that engineering design consists of a sequence of decisions which should satisfy the client's objective performance requirements. An assessment of geotechnical performance must involve ground displacements, and the traditional approach of specifying safety factors is potentially wasteful. In particular, the Limit State Design (LSD) approach adopted in the Eurocodes is shown to lack objectivity and therefore to be inadequate to the needs of clients and society at large. Improvements were proposed through the adoption of Mobilizeable Strength Design (MSD) principles in which the designer explicitly considers the stress-strain behaviour of the ground. Central to the MSD approach is an assessment of the possible deformability and strength of the soil that lies within the anticipated deformation mechanism of the proposed geo-structure. Displacements are then calculated by applying the principle of conservation of energy to the deformation mechanism. This leaves the designer with an implicit assessment of deformations before any other checks which might later be made by Finite Element Analysis (FEA), and ensures that the intended design performance can always be checked by monitoring during construction. Examples of the application of MSD included earth retaining structures, slopes and foundations.

The Rankine Lecture is hosted each year by the British Geotechnical Association. It is widely viewed as the most prestigious of all the invited lectures in Geotechnical Engineering world-wide and is attended by an international audience of around 1000 people. For the first time this year the talk had a live web cast and had the largest audience ever for this lecture.

Professor Bolton's Rankine Lecture is available to watch at www.cpdlectures.com/Lecture.aspx?id=113

Hackathon Victory for Data Scientists

Data scientists from the Department of Engineering formed part of the winning team in the first ever global Data Science Hackathon.

The winning team

Research Associate Dr Jose Miguel Hernandez Lobato and PhD student Ferenc Huszar were among a group of four data enthusiasts making up The Londoners team which won £1,200 in the competition by developing an early-warning system for air pollutants. Jose Miguel and Ferenc are both part of the Machine Learning Group within the Computational and Biological Learning Lab.

The hackathon was held to promote Data Science and to show what can be achieved by combining Data Science with Open Source, Hadoop, Machine Learning and Data Mining tools. In addition, the event also aimed to promote the sense of community, team work and free spirit competition aspects of Data Science.

The competition challenge was to improve the US Environmental Protection Agency's Air Quality Index by designing a better and more accurate predictive model of metropolitan air pollution. The EPA's Air Quality Index is used daily by people suffering from asthma and other respiratory diseases to avoid dangerous levels of outdoor air pollutants, which can trigger attacks.

Ferenc commented: "According to the World Health Organisation there are now estimated to be 235 million people suffering from asthma. Globally, it is now the most common chronic disease among children, with incidence in the US doubling since 1980. The model we built could be used as the basis for an early warning system that is capable of accurately predicting dangerous levels of air pollutants on an hourly basis."

Over 200 data scientists from several cities around the world participated in the competition. The non-stop 24 hour event took place at venues in London, San Francisco, Chicago, Boston, New York, Canberra, Melbourne and Turku (Helsinki).

Nanotubes used to create smallest ever hologram pixels

A breakthrough in the use of carbon nanotubes as optical projectors has enabled scientists to generate holograms using the smallest ever pixels.

DR HAIDER BUTT

Hologram

"These results pave the way towards utilising nanostructures to produce 3D holograms with wide field of view and the very highest resolution."
Dr Haider Butt

Scientists have generated holograms from carbon nanotubes for the first time, which could lead to much sharper holograms with a vastly increased field of view.

The researchers from the Department of Engineering's Centre of Molecular Materials for Photonics and Electronics (CMMPE) have harnessed the extraordinary conductive and light scattering abilities of nano tubes - made from several sheets of carbon atoms rolled into a cylinder – to diffract high resolution holograms.

Carbon nanotubes are one billionth of a metre wide, only a few nanometres, and the scientists have used them as the smallest ever scattering elements to create a static holographic projection of the word CAMBRIDGE.

Many scientists believe that carbon nanotubes will be at the heart of future industry and human endeavour, with anticipated impact on everything from solar cells to cancer treatments, as well as optical imaging. One of their most astonishing features is strength – about 100 times stronger than steel at one-sixth of the weight. The work on using these nanotubes to project holograms, the 2D images that optically render as three-dimensional, has been published in the journal 'Advanced Materials'.

"Smaller pixels allow the diffraction of light at larger angles – increasing the field of view. Essentially, the smaller the pixel, the higher the resolution of the hologram," said Dr Haider Butt from CMMPE, who conducted the work along with Yunuen Montelongo. "We used carbon nanotubes as diffractive elements – or pixels – to produce high resolution and wide-field-of-view holograms."

The multi-walled nanotubes used for this work are around 700 times thinner than a human hair, and grown vertically on a layer of silicon in the manner of atomic chimney stacks.

The researchers were able to calculate a placement pattern that expressed the name of this institution using various colours of laser light – all channelled out (scattered) from the nano-scale structures.

For Haider this is just the start – as these pixels and their subsequent displays are not only of the highest resolution, but ultra-sensitive to changes in material and incoming light.

"A new class of highly sensitive holographic sensors can be developed that could sense distance, motion, tilt, temperature and density of biological materials," he said.

"What's certain is that these results pave the way towards utilising nanostructures to produce 3D holograms with wide-field-of-view and the very highest resolution."

For the researchers, there are two key next steps for this emerging technology. One is to find a less expensive alternative to nanotubes, which are financially prohibitive.

Haider commented: "Alternative materials should be explored and researched. We are going to try zinc oxide nanowires to achieve the same effects."

The other is to investigate movement in the projections. Currently, these atomic scale pixels can only render static holograms. Haider and his team will look at different techniques such as combining these pixels with the liquid crystals found in flat-screen technology to create fluid displays – possibly leading to changeable pictures and even razor-sharp holographic video.

Building our capacity to endure

Building Design magazine highlighted the work of six sustainability 'stars' from Cambridge. The range of work they do gives us an overview of just how broad the meaning of sustainability is.

Peter Guthrie, Director of the Centre for Sustainable Development.

Koen Steemers, Head of the Department of Architecture

Julian Allwood, Leader of the Low Carbon Materials Processing Group

Holly Knight

Alasdair Young

Clive Fussell

The UK government's Climate Change Act of 2008 committed this nation to an ambitious but essential aim – an 80% reduction of greenhouse gas emissions by 2050. That this goal has been set is an important step, showing the UK's commitment to edging humanity back from the ecological brink, but the absolutely critical step will be meeting it.

The demand and consumption of energy that leads to the annual pumping of millions of tonnes of carbon and other damaging gases into the atmosphere is beginning to render our existence as a species quite literally unsustainable.

'Sustainability' is often used as common parlance for vague notions of eco-friendly activity – but in truth it is far more fundamental. Internet godhead Wikipedia describes sustainability as "the capacity to endure" – essentially, ensuring our future. Sustainability is the best humanity can hope for – and it's going to be an uphill struggle all the way.

Central to the human fight for the "capacity to endure" will be the people who design and build the stuff that facilitates our lives – and consequently requires the energy – the infrastructure, buildings and materials that millions rely on in the 21st century. Earlier this year, to coincide with the Ecobuild 2012 – the world's biggest sustainable construction design conference – the architecture newspaper Building Design drew up a list of the UK's 50 most influential figures in sustainability: three of whom are Cambridge academics – Peter Guthrie, Koen Steemers and Julian Allwood.

Peter Guthrie is the first Professor in Engineering for Sustainable Development in the UK, a post he has held since 2000. With a background in civil engineering, Peter has worked on road networks and major infrastructure projects in developing countries, and around the world, for decades. In 1980, after working in a refugee camp during the Vietnamese Boat People crisis, he founded RedR, a charity that provides engineers to relief agencies in disasters. At Cambridge, Peter is Director of the Centre for Sustainable Development, where he directs research on the Energy Policy and Efficiency in the Built Environment programme, among others. He has advised on environmental policy for many countries and worked on many major projects including London 2012, Channel Tunnel Rail Link, and Birmingham, Liverpool and Manchester Airports.

"In the Centre, our research seeks to grapple with the many facets and multi-disciplinary nature of sustainable development, embracing and addressing social, economic and environmental aspects together and in their complex interaction," says Peter. "Achieving moves towards the change in the way development is delivered requires new approaches and we are seeking to define these and work with new approaches."

Koen Steemers is Professor of Sustainable Design and Head of the Department of Architecture at Cambridge. One of his focusses is energy demand in cities, looking at design software that informs urban building for effective use of lighting, heating and ventilation. Buildings account for 50% of the carbon emissions in the UK, but human perception is rarely considered as a major factor.

"At the moment, a truly vast amount of the world's energy consumption – around 38% of its total – is accounted for in buildings, often as a result of the attempt to provide an artificially uniform environment," says Koen.

"We need to enhance the technical potential of design, environmental systems and controls supporting energy efficient behaviour. Refurbishing existing buildings is a priority – 80% will still be here in 2030." Koen is the author of 10 books including Sustainable Urban and Architectural Design (2006) and Environmental Diversity in Architecture (2004).

"The design of sustainable buildings and cities is about much more than reducing the demand of non-renewable resources – it is about providing beautiful environments to live, play and work in. It is critical to ensure that the quality of the built environment is improved hand-in-hand with improved technical performance to deliver 'win-win' solutions."

Julian Allwood is a leader in the sustainable materials field, and heads up the Low Carbon and Materials Processing group in the Department of Engineering. The group is dedicated to seeking out and developing opportunities for engineering to contribute to a low carbon future, particularly reducing energy demand in big industry – an area vital to the government's targets.

Along with his team of researchers, Julian has produced the first study on transforming an industrial sector, textiles, to have sustainability as its goal – and how to move to localised production, identifying practical steps at business unit level to reduce carbon emissions.

As described on page 3, a recent development has been the research into 'un-printing', using lasers to remove ink from scrap paper – allowing the paper to be reused, without being discarded, shredded or sent to a recycling plant.

"This could represent a significant contribution towards the cause of reducing climate change emissions from paper manufacturing," says Julian. "Thanks to low-energy laser scanners and laser-jet printers, the feasibility for reusing paper in the office is there."

If we are to make the 80% reduction in greenhouse gas emissions by 2050, sustainability in construction and engineering will be fundamental – for the UK and the state of our planet. These three academics represent a small part of Cambridge's collective efforts in the fight for all our futures.

In another list but this time of the 'Top 50 rising stars of sustainability' two students and one graduate from the Interdisciplinary Design for the Built Environment (IDBE) masters course, run jointly by the Departments of Engineering and Architecture, have been named. Building magazine scoured the construction industry to find the next generation of sustainable

leaders – people who have grown up in a world where environmental issues have always been a talking point and who refuse to accept this part of their roles as merely an 'add-on'. Among them are two students, Holly Knight and Alasdair Young, as well as a graduate of the course Clive Fussell.

As well as being named in the 'Top 50 rising stars of sustainability', Holly Knight has also been listed in Building Design Magazine's 'Top 50 Green Leaders', dubbed as the '50 most influential people in UK sustainability'.

Holly Knight, 33, is Principal Sustainability Manager with the Olympic Delivery Authority. A specialist in water, she regards her most significant sustainability achievement as working on the Old Ford waste water recycling plant on the Olympic park. Holly joined the IDBE course in 2010 and led a guided tour of the Olympic park in June 2011 for her student cohort.

Alasdair Young, 32, Associate, Buro Happold, completed his MEng in mechanical engineering at Cambridge in 2003 gaining first class honours, and joined the IDBE course in 2009. As a senior engineer in Buro Happold's Sustainability and Alternative Technology group, he has worked on numerous projects involving sustainable energy, water and waste systems. In addition to being the group's champion for combined heat and power, he has also worked on low carbon technologies such as biomass and large scale wind power systems. He co-authored the influential report 'Powering ahead: delivering low carbon energy for London'.

Clive Fussell, 39, joined the IDBE course in 1999 and graduated in 2002. A structural engineer formerly with Buro Happold, he is a founding partner with another IDBE graduate Paul Grimes, of the engineering consultancy Engenuiti. Among a wide-ranging engineering portfolio, the practice has been appointed engineering consultant for a number of low carbon schools constructed using cross-laminated timber panels.

"At the moment, a truly vast amount of the world's energy consumption – around 38% of its total – is accounted for in buildings."
Professor Koen Steemers

Building magazine's 'Top 50 rising stars of sustainability' can be found at: www.building.co.uk/technical/sustainability/top-50-rising-stars-of-sustainability/5032914.article

Top honour for Engineering alumna

A graduate from the Department of Engineering has been named as one of thirty young rising stars of the manufacturing world.

'Make it in Great Britain' is a Government initiative to help highlight and celebrate British manufacturing. The 'Make it in Great Britain' campaign has chosen thirty young rising stars of the manufacturing world – '30 Under 30' – of which alumna Sakthy Selvakumaran is one. The 24-year-old was described by the judging panel as being "a true high-flyer, standing out from her peers and demonstrating passion, enthusiasm and ambition in her role."

The young professionals were selected by a panel of expert judges and come from all walks of manufacturing. They include young talent from companies such as Pendennis Shipyard and GlaxoSmithKline as well as small and medium-sized enterprises such as The Paper Cup Company and Vantage Power.

All aged under 30, the finalists will now go on to act as ambassadors for the 'Make it in Great Britain' campaign, which aims to transform the image of modern manufacturing. They will have a special role in engaging with other young people, to ensure that the next generation is aware of the opportunities and careers in the engineering industry.

Sakthy graduated in 2010 and now works full time on civil structures as a member of the engineering team at Ramboll. She spent most of her holidays before graduating assisting with a number of projects including the assessment of bridge upgrades for the enlargement programme of the Docklands Light Railway. For her masters research project, Sakthy carried out an analysis of micro-hydroelectric power schemes in the remote Peruvian Andes, undertaking both desk research and working out in the field. Immediately after graduating, Sakthy worked in Spain for a year with Davis Langdon and with the charity, Engineers Without Borders UK, having won the opportunity through a 2011 Vodafone World of Difference Award. She was also part of a team awarded a Commendation in the Society of Public Health Engineers' Young Engineers Award 2011.

Visiting the Engineering Department's Baker Building to meet year 12 students attending a summer workshop, Sakthy told the aspiring engineers: "The opportunities here in the Department of Engineering are endless. Whatever you want to do you will find someone prepared to help you. I thoroughly enjoyed the challenges and experiences of my time in Cambridge."

She added: "There are a wealth of jobs in manufacturing – from the conception and design of new technologies and processes through to actually delivering and making them. I am passionate about highlighting the exciting opportunities on offer to encourage young people to give real consideration to engineering and manufacturing careers, which are a rewarding way of using your skills to create solutions for society's most pressing challenges. As a sector we need to encourage fresh talent into the industry."

NEW CIVIL ENGINEER MAGAZINE

"I am passionate about highlighting the exciting opportunities on offer to encourage young people to give real consideration to engineering and manufacturing careers."
Sakthy Selvakumaran

An obvious advocate of engineering as a career, Sakthy encourages university applications from minority ethnic groups and youths from disadvantaged areas through mentoring and speaking at events and is thoroughly enjoying her role as a '30 Under 30' ambassador.

Paul Jackson, CEO of Engineering UK and one of the '30 Under 30' judges said: "I am always impressed at the level of young talent present in manufacturing and engineering, and over the years have met countless young people brimming with potential who have gone on to achieve great things.

"That is one of the reasons why I am supporting 'Make it in Great Britain' and why I was happy to be a judge for the '30 under 30'."

The 'Make it in Great Britain' campaign aims to challenge outdated perceptions of the UK manufacturing industry, which is worth approximately £137bn to the UK economy each year and employs 2.5 million people.

How offshore wind turbines could be more efficient

A Department of Engineering study suggests that offshore wind farms could be 100 per cent more efficient in terms of energy payback if manufacturers embraced new methods for making the structures that support the turbines.

: PHAULT (FLICKR)

Wind turbines in the Thames estuary with heavy supporting structures under water

As wind farms are increasingly sited offshore rather than on land, and installed at water depths of up to 40 metres, a Cambridge University engineer is urging the wind power industry to look again at the design of the heavy supporting towers and foundations used out at sea in order to improve the energy payback achieved.

Jim Platts of the Engineering Department's Institute for Manufacturing (IfM) believes that the wind power sector could achieve significantly higher payback ratios if turbine manufacturers used guyed towers (towers held in place by steel cables) made in composite materials rather than free-standing towers made in conventional steel materials.

A preliminary study undertaken at the IfM suggests that payback ratios for offshore wind farms could be doubled if the industry embraced new construction methods.
Jim says: "The development of the wind turbine industry, and the way in which it works with the civil engineers who make the heavy supporting towers and foundations, which are not visible out at sea once the turbines are installed, mean that we have ignored something which is almost embarrassingly obvious in our race to meet the targets set for renewable energy production.

"We urgently need to reduce the high levels of energy embedded in offshore wind turbines which make them both ineffective in energy payback and costly in financial terms. We can do this fairly easily if we invest in more innovative methods for making and installing the towers and foundations that support them."

The effectiveness of wind turbines is determined by a key figure: the harvesting ratio. This ratio is a measure of the energy it provides set against the energy embedded in it (energy used in manufacturing it). Wind turbines comprise four main elements: the blades that harness the wind energy; the gearbox and generator mechanisms that produce the electricity; the tower that supports these moving parts and the foundations that hold the tower in place. The tower is conventionally made of steel and the foundation in steel and concrete.

For a turbine designed for use on land, the energy embedded in the moving parts represents two-thirds of the total energy invested in the installation while the supporting structure (tower and foundation) represents the remaining third. Onshore turbines typically achieve a harvesting ratio of 40:1.

When wind turbines are sited offshore, the towers required are both taller and heavier and the foundations more massive, using up to four times the amount of steel and concrete. "When you look at offshore wind turbines you see a series of slim structures – what you don't see are the far heavier supporting structures below the surface that they slot into," explains Jim. Both steel and concrete are highly energy intensive to produce so the harvesting ratio of offshore turbines reduces to typically 15:1 – far lower than for onshore turbines.

On top of this, offshore turbines are subject to corrosion, which reduces the lifespan of the steel used. "Steel is prone to corrosion and to fatigue," comments Jim. "This begs the question: could we do better with other materials. The answer is yes, we can use composites for towers just as we do for blades. They are lighter, stronger, corrosion free and more resilient than steel."

A preliminary study undertaken by the IfM suggests that guyed towers offer significant advantages over conventional towers. The use of steel cables, fixed to the sea bed by screw anchors, means that towers can be significantly slimmer as the tent-like guyed shape distributes the loads more efficiently to the seabed. Similarly, the foundations required are substantially less weighty.

The resulting reduction in the volume of steel and concrete needed means that a harvesting ratio of 25:1 can be achieved, the study concluded.

"The use of guyed towers is just the first step for the industry to take. The second step would be to make towers in composite materials which are less energy intensive to make than steel which relies on smelting and concrete that also depends on a chemical reduction process in manufacturing cement. Composites also have a longer life than steel as they stand up to fatigue much better. Using these new materials could increase the harvesting ratio still further to 32:1 and extend the lifetime of a turbine installation from the present 20 years to up to 60 years," says Jim.

"The Finnish wind turbine manufacturer Mervento has shown the way with a guyed turbine designed for use in the Baltic. Other producers – such as those making turbines for sites in the North Sea – need to take heed and invest in research into designs that take a similar approach to making the industry far more energy efficient and sustainable."
The wind turbine industry has experienced an average of 25 per cent per annum growth over the past 20 years. It has pioneered many composite materials developments that have benefited other sectors, such as aerospace. Wind turbine manufacturers use ten times more composite materials than the car and aerospace industries combined.

"It's often overlooked that manufacturers of turbines have driven advances in composites, producing materials with 95 per cent of the performance of the high-cost composites made for the aeronautical sector at 5 per cent of the cost. Much of this work has been led by UK companies. These companies now need to look at new ways of working," says Jim.

In the 1980s, Jim Platts developed the designs, the manufacturing processes, the team and the company that made all the large wind turbine blades in the UK. That team is now the Global Blade Technology division of Vestas, the world's largest wind turbine manufacturing company.