Issue 3 • Summer 2006

Newsletter

UNIVERSITY OF CAMBRIDGE
Department of Engineering

In this issue...

Executive Introduction

Winning photo 'Tails from the nozzle bank' by Dr Steve Hoath.

The Epson Photography Competition at the Department of Engineering produced a fine winner: Dr Steve Hoath, a Research Associate working with the Director of the Inkjet Research Centre, Dr Graham Martin, at the Institute for Manufacturing. Steve took the picture of ink drops 50μm in diameter hurtling from printer nozzles at 6m/s using high speed flash photography. Epson donated the first, second and third prizes. The winning photographs together with the runners up can be found via the link on the Department homepage (www.eng.cam.ac.uk).

Lord Broers came to Cambridge at the end of April to chair an independent review of the Department by an International Visiting Committee, which completes one of the major actions arising from our strategy. The Committee found all of the Department's research to be of the highest quality and relevant to real world applications. Nevertheless, they warned that there was no room for complacency and provided advice on how to develop our plans. The Committee will return to provide this vital external view of our work every two years.

During his visit to chair the Committee, Lord Broers joined Professor Alison Richard to open the new Electrical Engineering Building officially. Further developments on the West Cambridge Site are being planned, but we are also taking a fresh look at the Trumpington Street Site to establish a long term vision of how we will use this valuable location to greatest advantage and determine the practical steps to achieve our vision. We need to develop these facilities, as we push ahead with academic appointments to reinforce the core strengths in our six divisions and also develop our three themes: sustainable development, engineering for life sciences and cognitive systems engineering. A number of appointments have been made recently and many more are in the pipeline.

We are playing a significant role in the University's 800 year anniversary fundraising campaign to attract support for all of these plans, as shown by the examples given overleaf.

- Dr David Hibbitt (a founder of ABAQUS, Inc. and a former student in the Department) and his wife Susan have donated $4 million to endow a post in solid mechanics. This will enable the Department to recruit an outstanding candidate at lectureship level with the potential to rise through a competitive process to a professorship. The story of this major gift is presented inside the newsletter.
- MathWorks, the creators of the mathematical modelling tool MatLab and long-established collaborators with the Department, made a generous donation last year to support PhD studentships and undergraduate bursaries focussed on the development of mathematical models for engineering applications.
- Professor Mike Gregory, Head of the Institute for Manufacturing, is leading a major initiative to strengthen our capability to translate ideas into practice and engage with industry locally, nationally and internationally. Fundraising is well advanced with over £10 million secured for a new facility, which is designed to foster the necessary multi-disciplinary work and links with industry. More funds are needed to bring the project to completion. Professor Gregory's contact details for more information are given below.
- Professor Ashby has provided initial funding to create the Ashby Scholarship which will support PhD students working on the mechanics of materials. Nearly half of the £400,000 needed has been raised. David and Susan Hibbitt have set us a fundraising challenge: they will provide up to £100,000 to match, £1 for £1, new donations received towards the scholarship, thus doubling the value of any such donations. If you are inspired by this challenge, then please get in touch using the contact details given below.

Other alumni have been in contact to make plans for donations and benefactions to support our plans for studentships, bursaries, posts, research, and facilities. More announcements will be made in due course.

Further information
Details of the Department's Inkjet Research Centre at the Institute for Manufacturing can found at www.ifm.eng.cam.ac.uk/pp/inkjet

Professor Mike Gregory would be delighted to hear from people who want to learn more about his initiative, to get involved, and to offer support (01223 338195, mjg@eng.cam.ac.uk)

If you would like to know more about the Ashby Scholarship, or would like to support the Scholarship by making a donation, please contact Professor Norman Fleck, Head of Mechanics, Materials and Design, (01223 748240, naf1@cam.ac.uk)

If you want to learn more about the Department's plans, activities and fundraising, then please visit our website at www.eng.cam.ac.uk, or contact Philip Guildford, Director of Research (01223 332671, pg28@cam.ac.uk).

Major donation to support solid mechanics

David and Susan Hibbitt.

David and Susan Hibbitt have set our fundraising campaign off to a fine start with a $4 million donation to endow a post in solid mechanics. The international search will soon begin to find the best candidate to fill this new post. The academic selected will join Professor Norman Fleck's team to push the boundaries of research in this area and communicate its importance to the next generation of engineers through undergraduate teaching.

David and Susan met when David was an undergraduate at Jesus College studying engineering. After graduating and a short period of work in the UK engineering industry, David and Susan moved to the USA, where David enrolled for a PhD at Brown University. David completed his PhD in 1972. The thesis involved computational mechanics based on finite element analysis. He worked with his supervisor to commercialise the software they had developed, which started a chain of events which led to the formation of ABAQUS, Inc. - a firm dedicated to the development of reliable software that engineers could use routinely on a production basis to perform advanced structural analysis.

The fledgling company, started in early 1978 by David together with his colleague Bengt Karlsson, operated initially from David and Susan's house. Paul Sorensen joined a year later, finding space for his desk in the front room, alongside Bengt and David, while Susan worked on the dining table. Over the years, the company grew rapidly to become a market leader with a suite of software tailored through close partnerships with industry to solving the toughest problems in solid mechanics. The convenience and interchangeability of the software programs, plus their reliability and robustness, make ABAQUS unique.

In October 2005, ABAQUS, Inc. became a wholly owned subsidiary of Dassault Systèmes, a world leader in 3D and Product Lifecycle Management (PLM) solutions. ABAQUS employs over 525 people worldwide, with headquarters located in Providence, RI, USA, and R&D centres in Providence and in Suresnes, France. ABAQUS has 29 offices for technical support, sales and services, plus a network of distributors in emerging markets.

Since this handover, David has been working with Susan to stimulate and support basic research in engineering and science, and education at the highest levels. Our Department is now a major beneficiary of their initiative and, as Norman Fleck says, "David and Susan's gift provides us with a wonderful opportunity to develop our work in the field of solid mechanics. We look forward to recruiting an academic of international stature to join our team."

EPSRC award £1.4 million to fund a 'Smart infrastructure' project

Smart infrastructure.

Dr Kenichi Soga, Dr Campbell Middleton, Professor Robert Mair and Dr Peter Bennett are part of a team who have been awarded £1.4 million from the EPSRC 'Wired and Wireless Intelligent Networked Systems' (WINES) research grant to fund a 'Smart infrastructure' project.

One of the greatest challenges facing civil engineers in the 21st century is the stewardship of ageing infrastructure. Nowhere is this more apparent than in the networks of tunnels, pipelines and bridges that lie beneath and above the major cities around the world. Much of this infrastructure was constructed more than half a century ago and there is widespread evidence of its deterioration. Tunnels, particularly old ones, are prone to being influenced by activities such as adjacent construction, for instance piling, deep excavations and other tunnel construction. Excessive leakage and pipe bursts are frequent and usually unanticipated. Importantly, underground structures often cannot be inspected when they are being used by trains or due to other physical constraints. Bridges are susceptible to corrosion from de-icing salts and subject to ever increasing demands as the legal weight limit of lorries has been progressively increased over the years. Vehicular impacts and scour to the foundations of both road and rail bridges have resulted in significant loss of life and major disruption to strategic supply and distribution links. Little is known of the long-term performance of such infrastructure. These uncertainties and the importance of safety to users and consumers prompted the initiation of recent research projects investigating the prospect of damage detection and decision making and the use of novel sensors to mitigate damage.

Future monitoring systems will undoubtedly comprise Wireless Sensor Networks (WSN) and will be designed around the capabilities of autonomous nodes. Each node in the network will integrate specific sensing capabilities with communication, data processing and power supply. The project will demonstrate how large numbers of sensors can be integrated into large-scale engineering systems to improve performance and extend the lifetime of infrastructure, while continuously evaluating and managing uncertainties and risks. This is a joint project between the University of Cambridge and Imperial College London and comprises an integrated research program to evaluate and develop prototype WSN systems. Dr Soga is the overall project leader and Drs Ian Wassell and Frank Stajano of the Computer Laboratory (formerly Department of Engineering academic staff) join the project as communication/security experts. The Imperial College London team consists of experts in water supply, communication and computer science. The main objective of this proposal is to develop generic/pervasive wireless sensor networks that allow sharing of equipment and communication tools for monitoring of multiple types of infrastructures. Three application domains will be studied in detail: (i) water supply systems, (ii) tunnels and (iii) bridges. The project will exploit common characteristics of different infrastructures to advance sensor network design. The complexity of the monitoring system requires the following research areas to be explored: sensor systems, wireless communications, autonomous systems, information management, programming and design tools, trust security and privacy, systems theory, human factors and social issues. Field trials will be carried out with London Underground Ltd., Thames Water, Yorkshire Water, Highways Agency and Humber Bridge. Intel Corporation will support the project with hardware for the trials.

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Sending email at the blink of an eye

A new invention could change the lives of millions of disabled people by allowing them to control a computer by raising an eyebrow. Developed by Oliver Williams and Professor Roberto Cipolla from the Department of Engineering, the software will be free to download and use, providing a much-needed method of input for those unable to communicate conventionally.

The system, code named VIM (Visual Inference Machine), provides an accurate way of tracking limited facial movement. Unlike other input systems, it only requires a webcam and portable computer, providing a cheap alternative to existing systems that can cost tens of thousands of pounds.

VIM allows users with limited movement abilities to control a user interface with facial movements, such as eyebrows, eyes, or mouth. Coupled with Dasher, an invention from the Department of Physics, VIM allows severely disabled people to type and send emails at speeds close to keyboard input.

VIM's inventors have decided to make the system "open source", meaning that anybody will be able to download or use the software without restriction. They hope that its final release in a few months will make things easier for thousands of people.

The system uses a webcam and unique software developed by the team to track intuitively the movement of one face feature. It can work from most angles and in all light conditions, making it suitable for mobile use in wheelchairs. Dasher, developed by the Cavendish Laboratory's Professor David MacKay, allows users to write quickly using a simple up and down movement, making input simple with VIM.

The adaptive nature of the VIM system makes it possible to control a computer using other movements that can be tracked by a camera. The team have also adapted it to control a pointer using hand movements on a desk, which could offer relief for regular mouse users suffering from repetitive strain injury (RSI).

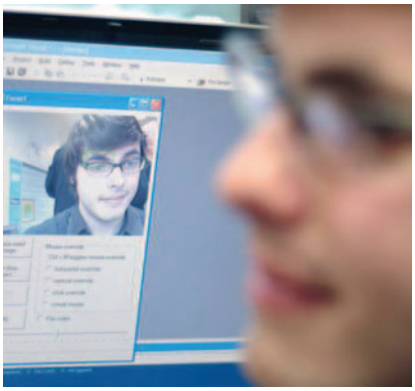

Photo courtesy of Holdsworth Associates.

VIM's development has taken nearly two years but the team are in the final stages of testing before offering it to users.

For more information please contact
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Intelligent airport

Professor Ian White and Professor Richard Penty are part of a multidisciplinary team who have been awarded £511,000 from the EPSRC for their project 'The Intelligent Airport: A self-organising, Wired/wireless Converged Machine'. The team also includes Professor Jon Crowcroft from the Computer Laboratory and colleagues at UCL and Swansea.
Diverse communications applications are expected to appear in the future with complex and often varying service requirements, traffic profiles and user expectations. These will require extremely advanced adaptive computing and communication systems to provide users with mobile, secure and automatic means of conducting business. A prime application area is in international travel which continues to grow supported by a significant investment in infrastructure, such as Heathrow Terminal 5.

An intelligent, adaptive, self-organising wired/wireless infrastructure is essential in this environment. It is anticipated that the considerable growth in the complexity of this infrastructure will not just be due to the proliferation of established fixed equipment such as wireless base stations, surveillance cameras, security detection equipment, display and terminal equipment. The requirements will also be for a much wider deployment of more compact portable equipment, for example, location and control equipment on a

Intelligent airport.

wide range of transportation equipment. Radio frequency identification (RFID) tags supported by a transparent optical-RF

network can be used to sense, locate and track an array of objects including luggage, mobile assets and commercial goods and can provide additional features such as boarding pass auto-tags and access control tags. Mobile biometric sensors will be widely deployed in this environment providing advanced features. A range of fixed and mobile terminals will provide additional security measures such as chemical detection and analysis, while other terminals, fixed and mobile, will support passenger information and entertainment services on transit. The infrastructure will support an array of personal passenger and staff wireless-media-rich devices. The wired/wireless network envisaged will thus be huge and complex, supporting perhaps 10 million information sources, with an anticipated peak aggregate data rate of the order 100 Gbit/s in a relatively local access environment. This is beyond the capability of any current network and research is needed to understand the principles upon which an effective system could be constructed.
This ambitious and multidisciplinary project is a collaborative programme. The project has strong industrial involvement and support from Laing O'Rourke who will provide the application context, share design experience, user requirements and architectural constraints, Red-M who will contribute propagation simulations and Ericsson who will contribute expertise in complex communication system design. BAA and Boeing have agreed to become involved in the project, providing expertise from the user perspective. Equipment companies, including Motorola, are involved to ensure that expert advice is received across all areas within the project.

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Designs on life

James Brown and Chris Field, fourth year students and Eva Cheng, a third year student here at the Department are part of a team from the University of Cambridge that took part in the first international Intercollegiate Genetically Engineered Machine (iGEM) competition. Dr Jorge Goncalves and Dr Glenn Vinnicombe, of the Information Engineering Division, were part of the team of instructors on the project. The event attracted students from all over the world to design and build machines made entirely from biological components such as genes and proteins. The Cambridge team worked on making a circuit that could control the movement of Escherichia coli bacteria. They aimed to engineer the bacteria to contain a switch governing their sensitivity to the sugar maltose. With the switch off, the microbes would ignore the sugar. Tripping the switch would make the bacteria sensitive to the sugar and induce them to move towards it.
The competition encourages the science of 'synthetic biology', which is a merger of life sciences and engineering. As the University of Cambridge students' brochure for the competition explains:

The University of Cambridge iGEM team for 2005.

"The core idea is that by drawing on knowledge developed from biology, and applying principles used in engineering design and production, it is now possible to create bio-synthetic systems to achieve novel applications with unprecedented power and efficiency."

"This research could lead us to a greater understanding of how life functions and how to use more effectively the very fabric from which it is created – DNA, proteins and cells. The possibilities of this technology are almost endless."

More information about the University of Cambridge iGEM team and their work can be found on their website at: http://www.syntheticbiology.co.uk/

Accurate targeting of radiotherapy for breast cancer treatment

A revolutionary way of targeting breast cancer tumours has been developed by the Department of Engineering's Medical Imaging Group led by Dr Andrew Gee, Dr Richard Prager and Dr Graham Treece and Cross Technologies PLC, producers of radiotherapy and x-ray imaging equipment.

The Stradwin three-dimensional ultrasound system, developed by the Medical Imaging Group, uses cameras to track the motion of an ultrasound probe, leading to a three-dimensional model of the tumour site for radiotherapy planning. Qados (a division of Cross Technologies PLC) is incorporating Stradwin technology with its own Osiris system to create Orpheus, a novel radiotherapy planning system that combines information from both laser surface scanning and three-dimensional ultrasonic imaging. The result is more accurate targeting of the tumour site, allowing reduced radiation doses with fewer side effects.

The radiotherapy suite at the Royal Marsden Hospital during the commissioning of the Orpheus system

The Royal Marsden Hospital, the largest comprehensive cancer centre in Europe, has already bought the Orpheus system and it is currently being installed there.

The Medical Imaging Group here at the Department has been working in the field of ultrasonic imaging since 1992 in close collaboration with the Department of Radiology at Addenbrooke's Hospital. They have had several important breakthroughs over the years:

2003: Developed the world's highest resolution freehand three-dimensional ultrasound system. This was achieved through novel approaches to calibration, correction of probe-pressure artifacts and a revolutionary "voxel free" structure for the system as a whole.

2004: Stradx freehand three-dimensional ultrasound system used in clinical applications, including discovery of hitherto unknown details of the anatomy of the brachial plexus. The research registrar won a best paper prize from the European Society for Regional Anaesthesia.
2005: Licensed the Stradwin freehand three-dimensional ultrasound system to Cross Technologies PLC for use in radiotherapy planning.

2006: Built a revolutionary hybrid freehand/mechanically-swept real-time radio-frequency three-dimensional ultrasound acquisition system, already in demand by other research groups.

2006: Developed unique high-performance algorithms for strain imaging (elastography). Strain images show the elastic properties of tissue. This can be important as, for instance, malignant lesions are often stiffer than their surroundings. The Medical Imaging Group has recently produced new algorithms that beat current commercial and academic competitors, leading to two patent applications. The Stradx system has been available on the web since 1997. It is focused on the requirements of engineering research. Stradwin, which provides a simpler user interface aimed at clinicians (and runs under Windows), was first released on the web in November 2004.

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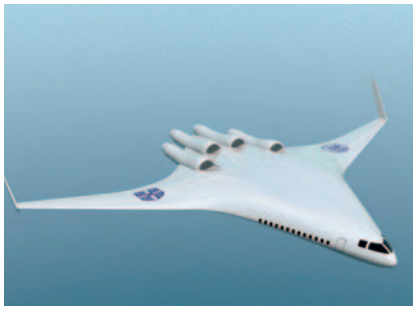
Racing green

Professor Anne Dowling 'Aside from safety, speed used to be the key priority in aircraft design.That's no longer the case. Our main concern now is to limit pollution.'



A simulation of the Silent Aircraft developed by Ann Dowling's research group in collaboration with colleagues at MIT.

"Our devotion to communicating face-to-face means we're travelling more than ever before," says Louise Simpson from the The Knowledge Partnership. But take heart. For Cambridge engineers are working to transform tomorrow's transport.

Here at the Department of Engineering Professor Nick Collings emphasises the need to develop cleaner, more efficient vehicles. 'There's still a lot of concern that something "green" won't be up to the job. But we now have very effective hybrid vehicles on the market that combine a gasoline engine with a battery-powered electric motor. Storing electricity generated by braking and using it for the next acceleration means you can fit a smaller, more efficient engine that gives the feel of a powerful car. When moving slowly or stopped in traffic you just switch off. This has a huge effect on fuel economy and cuts emissions by up to 90 per cent.'

Diesel fuel is economical but it puts more particulates – soot – into the air than gasoline, bringing health problems in its wake. Professor Collings' team are therefore working on bio-fuels and diesel particle filters, as well as on new combustion systems such as Homogeneous Charge Compression Ignition (HCCI). This combines traditional spark ignition with the sort of compression ignition a diesel engine uses. Combustion takes place evenly and spontaneously without the need for a flame, which means the engine can run efficiently over a much wider range than a conventional engine.

'The main problem with the average petrol engine is that in traffic its fuel economy is terrible,' says Collings. 'Using HCCI engines gives a petrol car the economy of diesel, while reducing the need for expensive catalysts and filters.'

To optimise an HCCI engine at the research and development stage, engineers need to be able to analyse its emissions with great accuracy. Collings' team have obliged with a series of ingenious diagnostic instruments that can do just that. By fitting a small sample tube to a modified spark plug, they can extract gas from the combustion chamber and analyse a tiny sample in real time while the engine is still running. Emissions can be measured on a millisecond timescale, a technique so important for the car industry that since 1987 their instruments have been sold commercially through a spin-off company called Cambustion.

With air travel expanding even faster than car use, Professor Ann Dowling concentrates her attention on the skies. The inventor of the jet engine, Frank Whittle, undertook much of his early development work as a mature student at Cambridge, and Professor Dowling builds on his legacy today as director of the University Gas Turbine Partnership, a long-running collaboration with Rolls-Royce that keeps Cambridge aero engineering at the cutting edge of technology. 'Jet engines are amazing,' says Dowling. 'The sheer density of the energy produced – equivalent to the power of over 1,000 family-sized cars, and within a volume not much larger than a single car – means that the engineering is highly sophisticated.'

'Aside from safety, speed used to be the key priority. That's no longer the case. Our main concern now is to limit pollution; and not just pollution from carbon dioxide. The water vapour emitted at altitude by burning fuel also drives global warming. You can reduce pollutants such as nitrous oxides by altering the design of the combustion system – which makes combustion research crucial – but the only way to reduce emissions of carbon dioxide and water vapour is to improve the overall efficiency of the engine and the aircraft.'

With global warming beginning to bite, is that enough? Shouldn't we be discouraging any increase in air travel? 'Jets give about 120 passenger miles to the gallon – better than a car,' says Dowling. 'It's very unlikely people will give up travelling by plane. The challenge is therefore to use the technology responsibly by improving efficiency and minimising the environmental impact.'

Noise is the other pollutant that Dowling's team are tackling, this time in collaboration with engineers from MIT under the aegis of the Cambridge-MIT Institute. The goal of their Silent Aircraft Initiative (SAI) is to design a passenger plane that makes no more noise at take-off and landing than the ambient urban noise outside the airport's boundaries. Since noise is hard to reduce through incremental changes, the team have gone back to the very basics of aircraft design and operations.

Computer simulations of the result reveal a radical redesign of what we think of as a jet aircraft. The Silent Aircraft looks more like a space craft ready to fight the Zargonoids on Zob than a plane to board for a business trip to Frankfurt: a sleek, white triangular shield with integrated wings and four stubby engines projecting from the back like organ pipes. The jets are slower and wider than on conventional planes so that they can produce the same thrust more quietly.

The integrated look contributes to the low noise performance, says Dowling. 'Noise at take-off comes from the engines. With a traditional jet, these are strapped to the underside of the plane, but the Silent Aircraft embeds them in the body, with intakes on top to shield the noise from the ground. On landing, half the noise of a conventional aircraft comes from the airframe; with the Silent Aircraft, the body is of composite construction rather than metal, and its streamlined shape reduces the noise.'

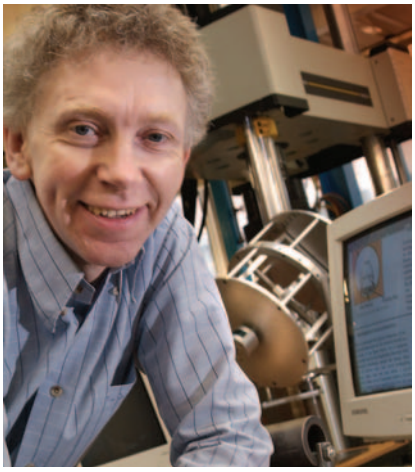
The Cambridge-MIT team is using computer modelling and scaled wind-tunnel tests to develop a virtual aircraft. The conceptual design will be completed by next autumn, and within twenty years we might even be boarding one of these new-wave planes for a commercial flight. For the moment, says Ann Dowling, the aim is to get industry to rethink its ideas about aircraft design. 'By ensuring that every component of the plane is as quiet as possible and has good efficiency, we hope to encourage manufacturers to be more radical in their targets for noise reduction.'

While Dowling is rethinking aircraft design, her colleague Professor Rex Britter is taking on air pollution. Inputting measurements such as volume of air traffic, wind, temperature and the pattern of surrounding buildings and traffic, he models air quality mathematically to estimate the impact of pollution on any given place. He is currently working with government on the air quality implications of the third runway proposed for Heathrow. But his techniques have security applications too: for instance, in helping decide how best to anticipate, and deal with, a terrorist release of air-borne toxins within a city.

Although the modelling is sophisticated, says Britter, estimating the damage pollutants will do to humans is difficult. 'The effect of traffic exhaust is hard to gauge. It depends on so many factors: heat, wind direction, how a city is built, where you site the sensors, and where people stand at the bus stop. Take Cambridge. You would think that the air quality would be good. But it's not, especially on Regent Street. We're on the edge of the currently acceptable threshold. The narrow streets and the large volume of cars concentrate pollution so that it can't easily disperse.'

There's no need to flee to the Hebrides yet, though, for Britter is remarkably upbeat about how seriously Europe is working to improve air quality. 'Regulations often push science forward, but the targets are almost too tight; our American colleagues think we're unwise to be chasing the thresholds that the EU has set. There is no perfect formula. If we live within very strict green limits there will be an impact on jobs, and therefore on our social lives and health. It's all about getting the right balance. To achieve the best air quality, we might have to forfeit the best transport links needed to support a leading economy. There are social consequences in everything we do.'

Britter is especially bullish about the interdisciplinary Institute of Aviation and the Environment he has just helped set up. This will tackle air pollution by bringing engineers together with economists, applied mathematicians, chemists, architects and geographers. 'Putting amazing teams together like this is the sort of thing that Cambridge does best. In fact, it's made me think that the colleges should become interdisciplinary centres, bridging business and the University, and providing the non-departmental think-tanks the world needs.'



Hugh Hunt 'Lots of countries have sorted out their inner-city transport problems by building underground railways, but the resistance here is incredibly high. It's a huge barrier to solving the big transport issue of the twenty-first century

David Cebon 'Lorries underpin our economy. They deliver our food and our supplies – we can't do without them. How many supermarkets are connected to railway lines?'.

One obvious route to reduced pollution is integrated public transport, a cause close to the heart of Australian-born engineer Dr Hugh Hunt. 'In many parts of Europe, the bus arrives at the train station a few minutes before the train leaves,' says Hunt. 'In Britain, we build the bus station a mile from the train station and forget to schedule connections.

'Lots of countries have sorted out their inner-city transport problems by building underground railways, but the resistance in this country is incredibly high. People under whose land tunnels might be built fear they will be disturbed by rumbles, and will get cracks appearing in their homes. It's a huge barrier to solving the big transport issue of the twenty-first century.'

Hunt himself is working on ways of controlling the vibration of underground trains to make new tunnels much quieter. 'Engineers and the public need to know what the impact on buildings will be, and our computer models show that vibration can virtually be eliminated,' he says. 'We need to persuade people, because tunnelling beneath buildings is a very important solution to urban traffic. Imagine what moving round London or Paris would be like now if those early engineers hadn't had the confidence to tunnel under buildings? We should be doing the same again today, only much better.'

Dr David Cebon's team are working on a variety of projects through the Cambridge Vehicle Dynamics Consortium, which brings truck manufacturers and researchers together to improve vehicles and promote best practice. Safety is high on the agenda. 'The congestion caused by lorry accidents and the damage lorries do to roads costs the British economy billions of pounds a year,' says Cebon. 'It's particularly bad here because we're so much more congested than the United States or Australia.'

A current project involves improving the way heavy goods vehicles take corners. At junctions and roundabouts lorries tend at present to cut the corner, causing damage and accidents or simply getting stuck. Now Cebon has created a breakthrough steering system for the back of the truck that will enable these giants of the road to negotiate much tighter curves. 'Whatever the speed, the back now follows the front. Whether blown by a side wind, avoiding an obstacle on the road or encountering ice, the vehicle remains on track. It's much safer and more manoeuvrable, with a lower risk of swinging out. It also uses less fuel and has much lower tyre wear.' Cebon expects such lorries to be commercially available in the next few years.

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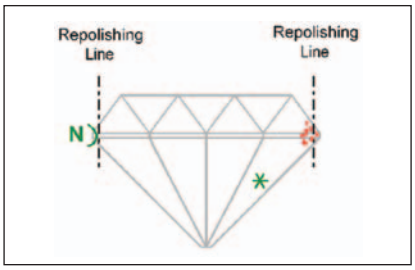
This article is by Louise Simpson of the communications consultancy 'The Knowledge Partnership'.

Diamonds cut quicker and with less waste

The value of a diamond depends on the four 'c's carat, colour, cut and clarity. The first three can be assessed objectively but the clarity is a more subjective assessment and hence the grade of a diamond, and therefore its value, can leave experts in disagreement. Dr Tony Holden, who specialises in improving decision making in business operations, and his team at the Department of Engineering's Institute for Manufacturing have developed a system to make the grading of diamonds and other precious stones more consistent. Tony and his colleague Matee Serearuno have developed an optimisation system called iGem that can grade stones effectively and calculate the best way to cut the stone to minimise waste.

Four diamond experts were asked to grade a set of 503 representative computer-generated stones and their opinions were then used as a set of rules for the iGem system. The model of the stone is fed into the iGem system. If a stone is borderline between two grades the system uses an Artificial Intelligence based optimisation technique to explore the different ways the stone could be cut to maximise its value, and keep waste to a minimum.

Tony is talking to Calibrated Diamonds, a company based in Johannesburg, South Africa, about combining his optimisation techniques with an advanced laser cutting system. John Bond, the founder of Calibrated Diamonds, says that this partnership will lead to a completely automated process that will reduce waste and reduce the turnaround time from months to days.



Example of Nomenclature used to describe features in precious stones.

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Plug-in solar power award

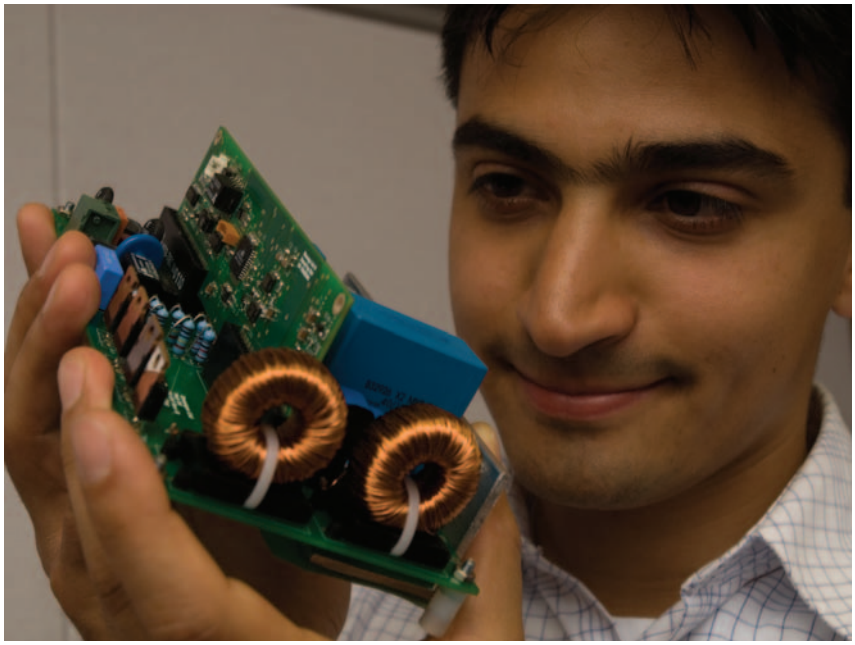
New technology could enable people to generate their own power economically at home and then feed it into the national grid on a very small scale.

Cuauhtemoc Rodriguez, a PhD student here at the Department of Engineering, has come up with a new generation of cheaper and smaller inverters for solar panels which can be plugged into standard electricity sockets.

He was awarded the Millennium Medal and Prize by Dr Brian Iddon MP at a reception at the House of Commons as part of the UK National Science Week 2006 Annual Presentations by Britain's Top Younger Scientists, Engineers and Technologists. More than 150 PhD students were shortlisted to present their research results at this prestigious event. Cuauhtemoc's winning presentation was titled 'Modular Photovoltaic Systems for Embedded Generation'.

The focus of the research is on the development of new electronic systems for efficient power conversion, in particular the problem of efficiently converting solar generated power so that it can be continuously fed into the standard domestic AC electricity supply. The output power from solar panels is DC (similar to that from chemical batteries) so an electronic interface is essential to convert it into electricity at 220 – 240 V 50 Hz AC whilst controlling variations in sunshine levels. The energy output from solar panels changes continuously as the level of light varies during the day. To maintain high efficiency when the power output from the solar panels is low is particularly challenging. Most solar installations which are connected to the grid need to be at least 1kW to ensure overall system efficiency can be maintained even in low sunlight conditions.

Cuauhtemoc's research is aimed at breaking this limit while maintaining high efficiency, to allow much smaller solar installations of around 100 W,



Cheaper and smaller inverters for solar panels.

requiring much smaller capital investment, to be connected to the electricity grid. Previous devices would need at least five solar panels to work whereas this technology only requires one. The reduced size, easy connectivity and integrated conversion unit allow these solar panels to be plugged into a standard power socket in a domestic building. Instead of drawing power from the socket, power will be fed into the system. The research has the potential to change how we generate our electrical energy, giving householders the opportunity to be electric power generators as well as consumers. Electric power generation using photovoltaic cells can thus become a truly consumer-driven technology.

Professor Gehan Amaratunga, Head of Electronics, Power and Energy Conversion in the Electrical Enginering Division , said: "Cuauhtemoc has made an outstanding contribution to the development and realization of this concept, as recognized by this award. This is very pleasing for us as the panel of judges recognized the significance of the modular photovoltaic panel concept for grid connection through the use of intelligent and efficient electronics. This is a concept which we have been pioneering since 1999." The work has been supported by Enecsys, a spin out company formed by two of Professor Amaratunga's former students at the Department of Engineering, Asim Mumtaz and Lesley Chisenga, to commercialise the small scale grid-connected solar panel concept which enables modular expansion of solar generation in an 'organic' manner.

Cuauhtemoc was one of five students from University of Cambridge sponsored by the Cambridge Environmental Initiative to attend the competition, which is organised annually by the SET (Science, Engineering and Technology) organisation for Britain as part of National Science Week.

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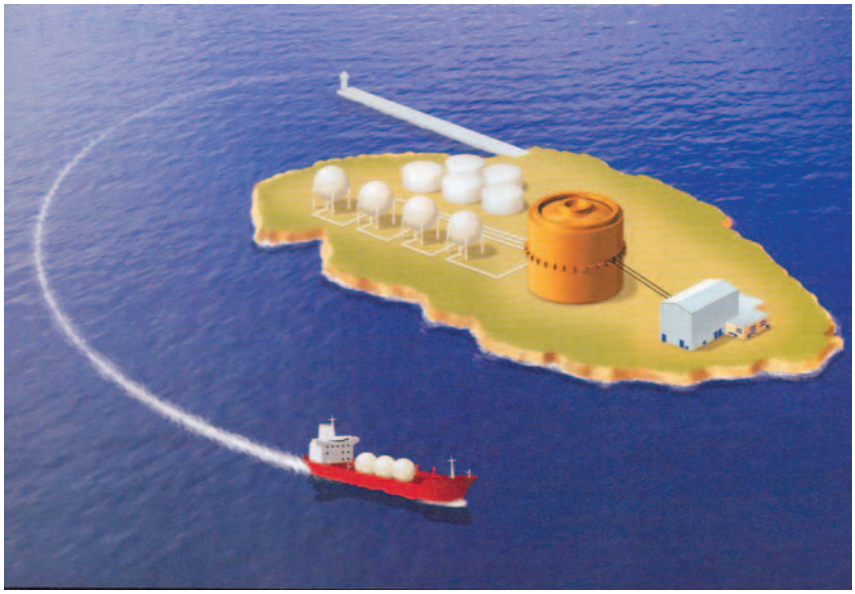
Fusion Island



Fusion Island.

Dr Bill Nuttall, who holds a shared post between the Judge Business School and the Department of Engineering, is part of a team who have won an award at the East of England Energy Group's (EEEGR) 3rd Annual Innovation Awards for their work on Fusion Energy.

Fusion energy, which is created by atomically combining two hydrogen isotopes at extremely high temperatures, is the holy grail of nuclear researchers. Working as an energy island, the 'Fusion Island' concept proposes a power plant built on an island, where fusion heat is used to split water, drawn from the sea into hydrogen and oxygen. On Fusion Island hydrogen is the coolant, the fuel, and the commercial product, sold in liquid form ready for transport by sea. A key innovation is that the powerful superconducting magnets needed to maintain nuclear fusion might be cooled not by expensive and scarce liquid helium but by the liquid hydrogen produced in abundance on Fusion Island. Creating clean fusion energy could be a way of tackling key environmental challenges in the coming decades.

About two years ago Bill became very interested in an idea coming out of a company called 'General Atomics' in San Diego, California. They said that nuclear fusion energy might be used to split water chemically at high temperature to make hydrogen to fuel cleaner vehicles. This way of making hydrogen could be a very efficient process.

At the same time Bill was concerned that it would be difficult for fusion to be reliable enough to make electricity commercially and also that electricity companies might be nervous about investing in fusion for that reason. He published an opinion piece in 'The Engineer' saying that the oil majors would be a good choice as developers of fusion energy and they could make and distribute hydrogen (i.e. not electricity).

A little less than a year ago he was at an event sponsored by the Cambridge Environmental Initiative and heard a Cambridge colleague, and now Fusion Island co-developer, Bartek Glowacki, say that the magnets for fusion might be cooled with liquid hydrogen rather than expensive liquid helium. Bill says "I was already imagining a fusion energy system surrounded by tanks of liquid hydrogen – his new idea was so good it almost knocked me off my chair."

Later Richard Clarke at UKAEA Culham, a European centre for energy research, pointed out that fusion might also use energy from hydrogen to fire up the whole system, so breaking all connections with electricity grids with all their related problems. Richard became the third member of the team.

So the Fusion Island concept was born – a new way of thinking about fusion energy serving new markets, with the potential for investors from new sectors, and with key benefits for sustainable hydrogen production to fuel the clean cars of the future. The team published an article about the concept in 'The Engineer' magazine last November.

Bill says "We have been aware of EEEGR for years and we respect their work and when we heard of the Innovation Awards we thought – 'perhaps they will be as excited by the Fusion Island concept as we are' – so we submitted a bid. We are very glad we did, as we received a runners up award."

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Dr Nuttall is author of a new book: 'Nuclear Renaissance – Technologies and Policies for the Future of Nuclear Power' (CRC Press).

Dr Bartek A. Glowacki from the Department of Materials Science and Metallurgy, University of Cambridge,
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Richard Clarke section leader JET/EFDA Cryogenics at UKAEA Culham
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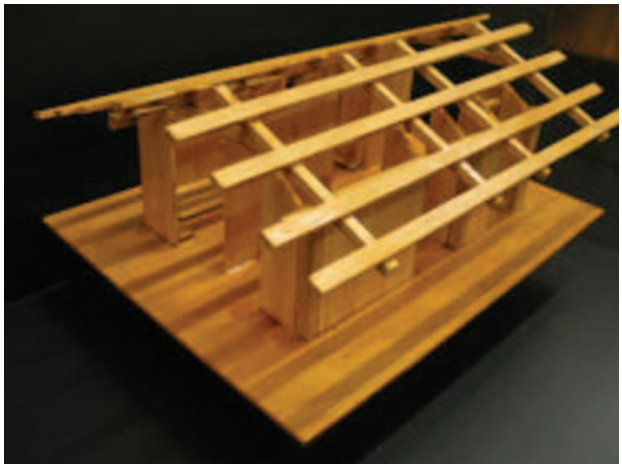
Tsunami-Safe(r) Housing

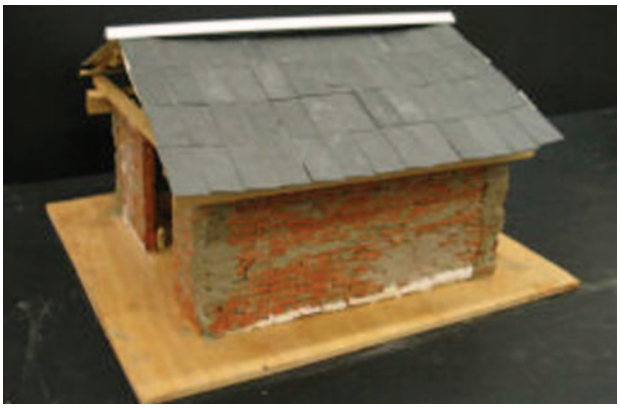
Dr Gopal Madabhushi and Dr I. Thusyanthan here in the Department of Engineering are testing a house that researchers from Massachusetts Institute of Technology (MIT), Harvard University Architecture Department and the engineering design company Buro Happold have designed with the aim that it will have a good chance of withstanding a tsunami wave. Dubbed the Tsunami-safe(r) house, their model for a Sri Lankan house is a unique combination of high-tech design and low-tech assembly that would allow waves to wash through it rather than knocking it flat. A house that can be built at around the cost of current house build costs in Sri Lanka and from readily available materials.

Gopal and his team have created a scale model (1/25th) of the prototype house which has been tested in a large glass tank in which the near-shore tsunami wave conditions have been created. The tsunami wave is created by dropping a heavy weight (~100 kg) into the water at the deepest end of the tank. The sudden displacement of water in the deep end of the tank creates the wave and the wave propagates to the shore where the model house has been placed. Instead of four solid walls, the new house design has four core columns made of concrete about three meters wide reinforced with metal rods. Walls of wood or bamboo are built in between the columns. The main aim of the design is the survival of the structure against a tsunami wave, thus the occupants still needs to be evacuated to safety prior to a tsunami. A scale model of a typical costal Sri Lankan house was also tested in the wave tank to show the tsunami wave induced damage to those houses.



Scale model of the prototype house.

Scale model of the prototype house.



Scale model of a typical Sri Lankan house.

A high speed (1000 frames/s) video camera is used to capture the tsunami wave as it hits and propagates past the model house. Miniature pressure sensors fixed to the walls of the building facing the wave front provide pressure exerted by the tsunami wave on the building walls. Pore pressure sensors set in the sand provides the data to calculate the speed and height of the wave as the wave passes over them. Sensors like these are currently being placed in the Indian Ocean off the coast of Sri Lanka in the hope that they will give a 1 to 2 hour warning of another tsunami. An early warning system using cellphones is also being designed by the University of Moratuwa in Sri Lanka.

Further information on the Tsunami-Safe(r) Housing can be found at: http://senseable.mit.edu/tsunami-prajnopaya/

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Micro-engines

A programme for research on millimetre scale internal combustion engines is being jointly developed by Cambridge Combustion Research Centre here at the Department of Engineering and the Centre for Micro-Engineering and Nanotechnology at the University of Birmingham. This micro-engine project brings together novelties in fabrication, combustion, and micro-engine design with a close interaction of micro-fabrication and combustion expertise.

Most liquid hydrocarbon fuels hold over 300 times more energy per unit weight than a NiCad battery and 100 times more than a Li-ion battery. A micro-engine would have the potential to release the energy from the fuels and possibly replace batteries in portable devices. It would not only last much longer than a battery of the same weight (about 20 times at 10% efficiency), but also requires little time to change its fuel capsule. As a highly compact energy source, micro-engines could find applications in medical devices, military equipment, PDAs, notebook computers, mobile phones, and even toys!

The original idea for making a micro-engine using Micro-Electro-Mechanical Systems (MEMS) technology was proposed by Alan Epstein and Stephen Senturia of Massachusetts Institute of Technology (MIT) in the mid-1990s. Research in Europe started at the University of Birmingham in 1999 and resulted in a patented fabrication process and several prototype micro-engines. The proposed collaboration project between the two Universities is intended to produce a micro combustion engine, with platform of 5 x 15 x 3 mm in overall dimension and the expected indicated power output at 11.2 W at a speed of the order of 50,000 rpm.

One of the major problems with the micro-engines is that silicon-based components cannot withstand the high temperatures of combustion. A second barrier is to actually produce sustained combustion in the small dimensions, which are affected by heat transfer.

Micro-engine

The solution proposed by the investigators is to make micro components out of ceramic materials, and to operate the engine at high speeds using autoignition processes to overcome the heat transfer problem. The investigators are hopeful that the development of the process will allow micro-engines to be brought to the market.

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Aviation's impact on the environment – A new EPSRC grant for multidisciplinary research

Economic development, increasing global linkages, and continuously declining airfares have made air travel the sector of fastest growth amongst all transportation modes. Although aviation has become significantly more fuel-efficient over the last 40 years, the associated decline in fuel use per passenger-kilometre flown has been offset by the strong growth in travel demand. As a result, there is a risk of emissions of pollutants such as NOX and particulates and of carbon dioxide and other greenhouse gases and their precursors continuing to increase. In light of the expected further growth in demand, the declining potential of mainstream technologies for increasing fuel efficiency will lead to a further strong growth in emissions. These growth trends require careful analysis to determine the potential implication of various policy tools (economic measures, aircraft technology, air traffic operation) on the environment and air transport system.

A team of investigators have been awarded a significant Engineering and Physical Sciences Research Council (EPSRC) grant to research the issues above. The investigators are all members of the recently founded University of Cambridge Institute for Aviation and the Environment (IAE) and together cover a broad range of research within the University. They are all leading researchers in the fields of aircraft engineering, atmospheric science, urban air pollution, and transportation systems analysis. That combination of knowledge and skills offers a unique opportunity to understand a holistic picture of the air transportation system and the environment. Members of the IAE collaborate with leading universities, industry, and governments worldwide. The principal investigator is Dr. Andreas Schäfer, a Lecturer at the Department of Architecture. Co-investigators are: Rex Britter, Professor of Environmental Fluid Dynamics, Department of Engineering and Bill Dawes, the Francis Mond Professor of Aeronautical Engineering, Department of Engineering. Peter Haynes, Professor of Applied Mathematics at the Department of Applied Mathematics and Theoretical Physics. John A. Pyle, Professor in Atmospheric Science. Roderic Jones, Professor of Atmospheric Science at the Department of Chemistry. The research will also benefit from the following collaborators; Dr. Jonathan Köhler, a Senior Research Associate at the Department of Applied Economics and Dr. Helen Rogers, a Research Associate at the Department of Chemistry and in charge of the IAE Research Liaison.

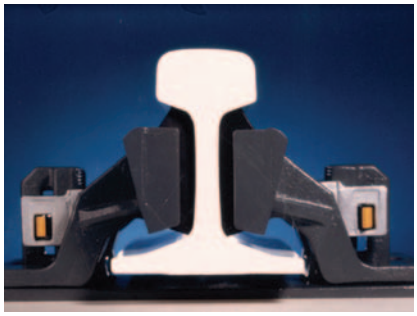
This grant compliments the large award received by the IAE from the Natural Environment Research Council (NERC) last year for Knowledge Transfer Activity.

Institute for Aviation and the Environment website:
http://www.iae.damtp.cam.ac.uk/

Vibration from Underground Railways Pipe-in-Pipe software – New Release

Floating-slab track, believed to be the most effective of all vibration countermeasures in new-build tunnels (Source: GERB,Germany)

Vanguard resilient rail support, possibly the best solution for retrofit in existing tunnels (Source: Pandrol Ltd, UK)



Vanguard resilient rail support. The resilience acts on the web giving low vertical stiffness with high lateral stability (Source: Pandrol Ltd, UK)

Software that will be a valuable resource for railway engineers responsible for the design of vibration countermeasures in railway tunnels has been developed here in the Department by Dr. Mohammed Hussein, Dr. Hugh Hunt and Dr. James Forrest. The software, called the Pipe-in-Pipe model (PiP), is a state-of-the-art application with a user-friendly interface combining accuracy and computational efficiency. It is available on the Internet as freeware.

Underground railways offer a cost-effective solution to traffic congestion in most cities, but vibration generated by trains is a concern to those living and working near railway tunnels. This vibration propagates from the wheel-rail interface through the tunnel wall and surrounding soil into nearby buildings. First, vibration can affect those living nearby directly when passing trains cause floors and walls to shake. Secondly, vibration can cause problems indirectly as reradiated noise. A third and very significant source of disturbance is due to movement of household objects, for example mirrors and windowpanes. These all have the potential to cause serious damage to buildings and distress to their occupants. These issues are of increasing concern to residents with the introduction of new underground lines in urban areas and a growing public sensitivity to noise and vibration. These factors have given rise to increasingly stringent legislation.

There are several techniques available to reduce vibration in buildings. Generally these involve some combination of resilient materials such as rubber, and massive sleepers or track beds. Some well-known techniques involve the use of rail pads, under-sleeper pads, ballast mats and floating slab track. Popular proprietary techniques include the Cologne Egg and Pandrol's Vanguard system. The right choice of vibration countermeasure and its specification is crucial because of the high financial cost and the difficulty of retrospective replacement.

Design engineers have become accustomed to designing vibration countermeasures using over-simplified models, with perhaps only one or two degrees of freedom. This is because of the substantial computational power required of the alternative models such as the Finite Element Method and the Boundary Element Method. The PiP model offers a high degree of accuracy by accounting for the essential characteristics of the track, tunnel and the ground while preserving low computational demands through the use of semi-analytical solutions of the elastic continuum in cylindrical coordinates.

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£14 million new home for the Electrical Engineering Division officially opened

The £14 million new home for the Electrical Engineering Division of the Department of Engineering is now up and running.

The striking building at West Cambridge, the University's growing science and technology campus, was officially opened at the end of April by Lord Broers, President of the Royal Academy of Engineering, and Professor Alison Richard, Vice-Chancellor of the University. They were joined by more than 150 guests from the University, industry partners and the local authority. The 4800 square metre building provides research and laboratory space and includes a 760 sq m clean room and the Centre for Advanced Photonics and Electronics (CAPE). There are more than 20 academics, 70 post-doctoral researchers and 150 post-graduate students.

The development spans end-to-end new technology development, from materials to components and sub-systems to finished systems. Areas of focus include displays, communications, sensors, including bio-sensors and smart power. CAPE is a strategic partnership with four major participants in the global photonics and electronics industry: Dow Corning from the USA provide materials, ALPS Electric from Japan components, Ericsson the European Partner provide systems and Europe and American company Advance Nanotech provide nanotechnological expertise and experience. Currently three of these Industrial Strategic Partners employ senior embedded researchers within CAPE. Between them they will contribute £10 million to research.

Other research projects in the building involve between ten and fifteen industrial funders.

Lord Broers, formerly Vice-Chancellor of the University and Head of the Department of Engineering, reflected on his aspirations when he had viewed the empty fields to the west of Cambridge several years ago. Professor Richard congratulated him on his vision and the Department on the breadth of its industrial collaborations and the quality and energy of its research.

The £14 million new home for the Electrical Engineering Division of the Department of Engineering is now up and running.

Assessing bridge strength

Dr Campbell Middleton has just secured funding for a project to investigate the effectiveness and economic benefits of a new technique for assessing the load carrying capacity of concrete bridges in the UK. This project promises to help save millions of pounds of tax payers' money by correctly identifying bridges in need of repair.

A research programme at the University of Cambridge in the early 1990s led to the development of what is believed to be the most advanced analysis software program for this purpose in the world. This has now been widely used in the UK by various highway authorities and their agents to re-assess the strength of bridges that were deemed unsafe using conventional methods of analysis. However, no study has been undertaken to examine the advantages and disadvantages of employing such advanced techniques, although anecdotal evidence suggests that it has resulted in very significant savings to the UK highway authorities.

In 1987, the Department for Transport introduced a national bridge assessment programme aimed at identifying those bridges on the national highway network that were in need of strengthening or replacement prior to the introduction of higher lorry weight limits in 1999 to comply with European legislation. In 1989, the local authorities in the UK started their own complementary bridge assessment and strengthening programme. This resulted in a massive programme of inspection, assessment, repair and replacement of bridges over the subsequent period. The total cost of this bridge rehabilitation programme has been estimated at £4 billion pounds. In 2006 many bridges have still not been assessed and others which were deemed to be under strength or inadequate are awaiting rehabilitation.

To put the significance of this issue in perspective, £131 million pounds were spent in the UK on bridge assessment

Concrete deterioration.

Concrete deterioration.

and strengthening and a further £72 million on upgrading during the period from 1988 to 1995 alone. A significant number of bridge assessments still remain to be completed under this rehabilitation programme, in particular those on the local road network. Thus, any analysis methods that can be shown to substantially improve upon our current assessment techniques could provide significant benefit to the country.

A recent audit of the national bridge assessment programme by consultant Parsons Brinckerhoff found that overly conservative or inappropriate analysis techniques had been employed in the majority of bridges examined in their study. As a result many bridges have been replaced or strengthened when in fact no such work was required.

The project funding is from the The Rees Jeffreys Road Foundation and will support a UROP (Undergraduate Research Opportunities Programme) student who will join the Bridge Research Group at University of Cambridge for the 10 week duration of the project. The UROP scheme, which originated at Massachusetts Institute of Technology (MIT) and has since been introduced at University of Cambridge, aims to give undergraduate engineering students experience in undertaking research and hopefully encourage them to consider a research career as a result of their experiences. They are employed as researchers over the summer vacation period working under the supervision of a member of staff. The UROP programme provides an ideal opportunity for small research projects to be undertaken whilst also helping train future researchers in the field.

Campbell has also secured funding from the The Rees Jeffreys Road Foundation to support a related second project which aims to undertake case studies of the actual cost of maintenance procedures on a sample of bridges on the highways agency network and perform whole life cost comparison studies on different maintenance strategies based on the data obtained.

In theory, management decisions on maintenance and rehabilitation choices for bridges are based on whole life costing principles and best value judgements. However, there are few, if any, publications giving a detailed explanation of how such evaluations should actually be undertaken or, perhaps more importantly, examples from existing practice demonstrating how this approach has been implemented. It is equally important to question how well expenditure on bridge maintenance matches that originally envisaged at the design stage.

In recent years the Highways Agency has commissioned a number of theoretical studies aimed at developing a preventative maintenance strategy for bridges but there is a perception that these rely heavily on theoretical optimisation algorithms rather than evidence obtained from existing practice. At present no such optimal maintenance strategy has been implemented by the Highways Agency.

The intention is to source the data required from the Highways Agency's Structures Management Information System (SMIS) database and also from records held by Maintaining Agency Contractors (MACS) around the UK. The researcher will firstly collect historical data on maintenance undertaken on a sample of bridges. Costs associated with the different procedures will be collated. A full whole life cost analysis will then be performed on a number of structures using the actual data obtained, and a comparison of outcomes presented. This will then be compared with planned maintenance strategies and cost predictions for the structures. In particular, the balance between lower capital cost and higher long-term maintenance outlays versus higher up-front expenditure in return for reduced disruption and future outlays will be examined. This research will be also be a UROP project over the summer vacation of 2006.

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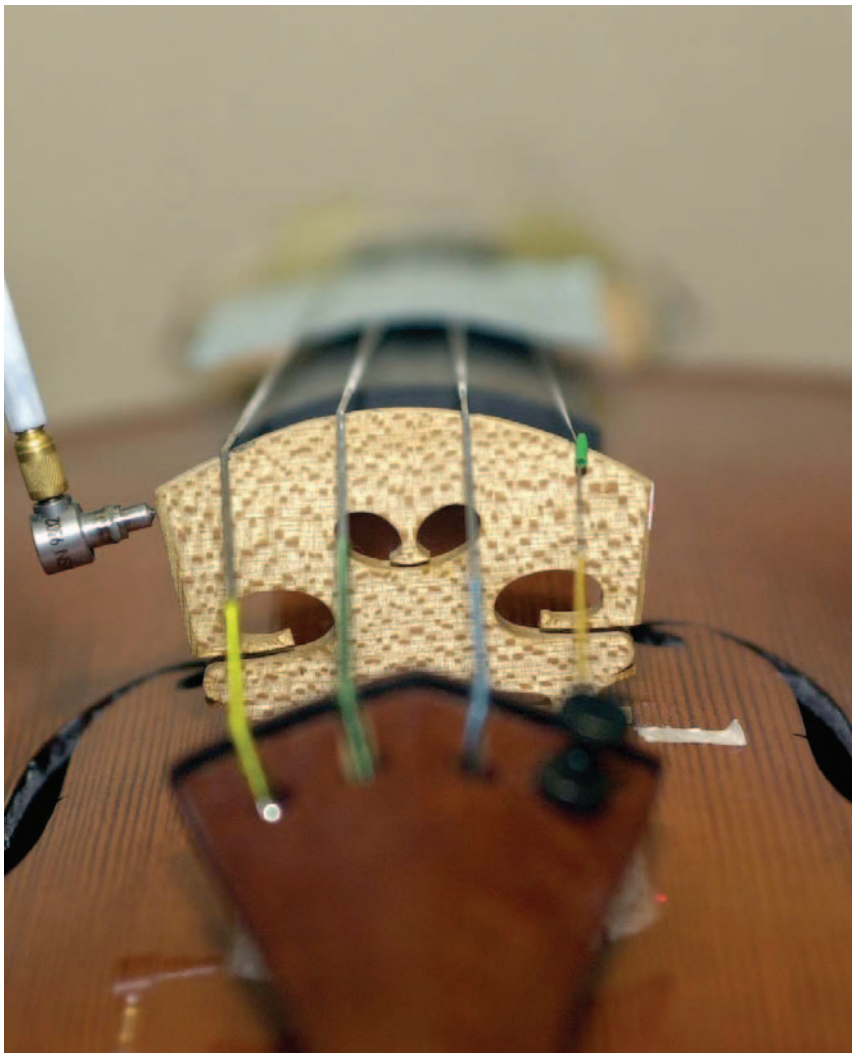
Experiments with a virtual violin



Measuring the response of a violin.

The question of why some violins are so much more valuable than others has fascinated musicians and scientists for a long time. Quite a lot is now known about the acoustics of the violin, but virtually nothing is known about the human capability for perception, discrimination and judgement of the sounds of violins with particular measurable acoustical properties. This is a very significant gap, since perceptual judgements obviously define what makes a violin different from other bowed-string instruments, and one violin different from another.

A project to fill this gap has recently been started by Professor Jim Woodhouse, involving a collaboration between three departments. Professor Jim Woodhouse and Dr Claudia Fritz from the Department of Engineering, Dr Ian Cross from the Faculty of Music and Professor Brian Moore from the Department of Experimental Psychology.

The ultimate aim of this research is to be able to answer the typical question that a violin maker will ask: "What will happen to the sound if I change such-and-such a constructional detail?". To answer this question, we start by measuring the forces recorded by piezoelectric sensors on a violin bridge, while the violin is being played normally. These recordings are stored as standard force functions, which can then be applied to different violins to hear how they sound without having to worry about any complications being caused by variations in playing. Instead of achieving this by using a robotic violinist which repeats the same piece on a variety of real violins, the tests are virtual. The standard force functions are applied to a computer model, which generates an accurate prediction of the sound of the violin using digital filters.

Once the violin response is represented in digital filter form, it becomes very easy to make controlled variations of a kind which would be almost impossible to achieve by physical changes to a violin. The typical process is to start from the measured response of a chosen violin, as illustrated in the picture, then use that as a basis for a number of modified "virtual instruments" in which, for example, individual resonances are changed in frequency, amplitude or damping. Psychoacoustical test methods can then be used to find the threshold for detection of any particular change, and also to obtain statistically significant data on quality judgements made by listeners.

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Grand Challenges

The Department of Engineering is one of a select group of UK academic institutions to win funding for ground-breaking projects that will tackle the challenges facing manufacturing in the 21st Century. A total of £21 million has been raised from government grants and industrial sponsorship for four 'Grand Challenge' areas.

The manufacturing Grand Challenges have been set up by the Government to encourage the UK's Innovative Manufacturing Research Centres (IMRCs) to address issues that have the potential for significant impact on national manufacturing priorities. The IMRCs are academic institutions recognized by the Government as being at the forefront of manufacturing understanding and research.
Of the five Grand Challenges to be funded the Department is involved in four:

- Innovation and productivity
- Life-time information requirements
- Micro-manufacturing
- Regenerative medicine – a new industry

Innovation and productivity
This Challenge aims to improve the way UK industry harnesses the outputs of research to produce high value products and services. The UK has a strong research capability in science, technology and engineering and a vibrant economy supporting industrial growth. However, to compete successfully in 21st century global markets, the research and industrial communities need to develop new ways of working together in order to achieve faster and more effective exploitation of research. Successful commercialisation of new ideas is seen as a key way to close the current productivity gap between the UK and other industrialised countries such as the US, France and Germany.

This Grand Challenge, which has been awarded £3.5 million of funding, is a joint venture between The Institute for Manufacturing (IfM), part of the Department of Engineering, and researchers at Cranfield, Imperial College, Liverpool and Loughborough universities.

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Life-time information requirements
Many engineering companies are undergoing a shift from product delivery to through-life service support. Firms are increasingly required to supply products and to provide support services throughout the product lifetime. This requires new business, operational and information system models that extend thirty years or more into the future. The overall aim of this research project is the identification of approaches to information and knowledge management that may be applied to the through-life support of long-lived, complex engineered products. The lifetime may be 10, 20 or 30 years and beyond, during which time the 'information and knowledge' will be stored, accessed, used and recreated many times over and in many different situations and contexts.

This Grand Challenge, which has been awarded just under £3.5 million of funding, the project team includes partners from Bath, Cambridge, Heriot-Watt, Lancaster, Leeds, Liverpool, Loughborough, Reading, Salford and Strathclyde universities as well as the Advanced Institute of Management initiative.

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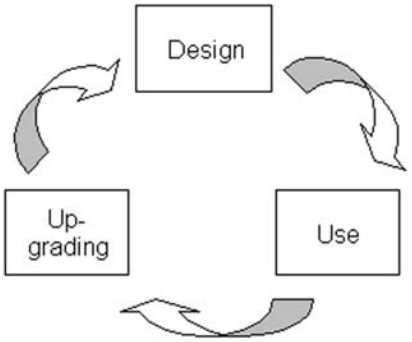

Life-time information requirements.

Micro-manufacturing
A radical new approach to the manufacture of miniature 3D objects will be the focus of this Grand Challenge, enabling UK business to be at the forefront of developing the next generation of electronic products in a wide range of sectors. The project, dubbed '3-D Mintegration', will establish new techniques to enable the production of genuine 3D, multi-material products in the automotive, aerospace, telecommunications, medical and consumer sectors.

Current micro-engineering techniques only permit the manufacture of products using single materials that typically have to be built up in multi-layer configurations. This £9 million, 4-year programme sets out to create a shift in manufacturing by developing the technologies and strategic approaches required to produce complex 3D miniaturized devices and assemblies.

The Institute for Manufacturing (IfM), part of the Department of Engineering, is collaborating with Cranfield, Greenwich, Heriot Watt, Loughborough and Nottingham universities as well as the National Physical laboratory. Twenty-three companies are also supporting the project.

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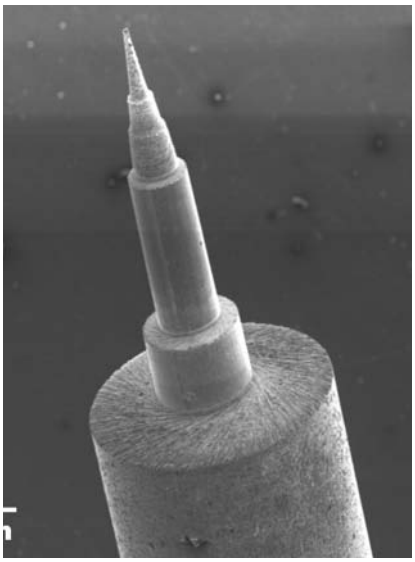
Micro-manufacturing – A micro-turned 'micro co-ordinate measuring machine' (CMM) stylus. Researchers will investigate how to manufacture these devices using a femtosecond laser.



Micro-manufacturing – Micro probe.

Regenerative medicine – a new industry

This Grand Challenge focuses on an emerging new healthcare industry that offers enormous potential to contribute to the UK economy. Regenerative medicine is an exciting branch of medicine in which cell and tissue based therapies can be used to alleviate and cure a wide range of conditions. It includes the fields of transplant surgery, tissue engineering, biomaterials and stem cell applications. Scientific research has already revealed the potential power of such activities. This project will focus on transforming established biology into commercial, affordable therapies.

The project has funding of over £5 million, is led by Loughborough University and includes collaborators from Nottingham, Liverpool and Ulster universities.

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PowerSilicon win prize at 'China UK Business Idea Competition'

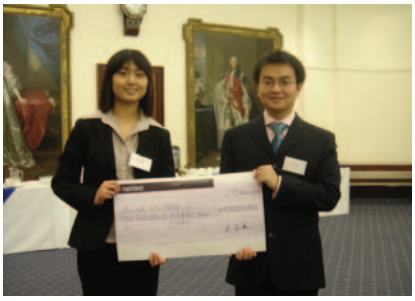
Zhihan Wang and Yalan Wang, two PhD research students here at the Department's Electronics, Power & Energy Conversion Group, have won second prize at the first 'China UK Business Idea Competition'.

Through three rounds of fierce competition in half a year, the team came second among 160 entries across the UK and won a prize of £1,000. They have also been granted a special award of one-year free business consultancy and a potential investment worth £20,000 from Fast Future Ventures.

The students' winning business plan "PowerSilicon Technology" is aiming to establish the first fabless power electronics design house in China. The idea is to turn the cutting-edge research work carried out in the Oatley Laboratory here into commercial technologies and market products. During their PhD research, they have developed innovative control strategies for power semiconductor devices and designed new generation power devices, which have promising potentials in the future markets in both China and the UK.

This competition is supported by organisations including the Chinese Embassy, UK Trade and Investment, East Midlands Development Agency, the Institution of Engineering and Technology (formerly IEE), China Council for the Promotion of International Trade and China Britain Business Council.

The winners have expressed their gratitude to their supervisor Dr. Patrick Palmer for his valuable advice and to the Head of the Group Professor Gehan Amaratunga for inspiring their entrepreneurship spirit.



Prize winners

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Inspiring the Engineers of the Future

Two recent events organised by the Department's Outreach Officer Dr Joy Warde have had a lot of very positive feedback from the pupils who took part. The events aim to excite school children about engineering .

Rocket Launch Pad
Around 300 children from 10 Cambridgeshire schools visited the Department of Engineering between 19th and 23rd June to complete a "Rocket Launch Pad" challenge. Rocket launch pad is designed to introduce primary school children (aged 7-11) to the creativity and fun of engineering. Small teams of pupils were challenged to build a rocket and launch pad using only paper, tape, nuts and bolts. The Rockets were then launched out on the fen, behind the Department.

The school visits were supported by a large team of enthusiastic and dedicated student volunteers who advise the teams on their design and help with the construction. These volunteers also act as engineering role models by sharing their own engineering experiences and answering pupil questions to help break down any misconceptions of what engineering is all about.

The children's school teachers were extremely positive about their visit. "Definitely one of the best educational trips I have ever taken children on". Reaction from the pupils was unanimous as summarized by a year 5 pupil "Thank you very much for letting us come to your brilliant University, to become young engineers, we had a fabulous time. We learnt a lot about engineering and structure building."

We hope some of these children will remember their visit to the Department of Engineering when making career choices in the future.

Techlinks 2006
From June 14th to 16th a total of some 1500 youngsters from all over the region descended on the Imperial War Museum, Duxford, to work on a variety of technologically based projects from making a jitterbug dancer to designing a hovercraft. This event, known as 'Techlinks' is organised by ExSciTE Ltd and SETPoint Cambridgeshire, the three day event is designed to enthuse school children from both primary and secondary schools about engineering. The core ethos of Techlinks is that wherever possible activities should be lead by engineers or scientists to promote a greater understanding of science, engineering and technology. This year 20 student volunteers from the Department and Cambridge University Engineers' Association (CUEA) members joined teams from ExSciTE Ltd and Science & Engineering Ambassadors to stage the technological challenges. Event organisers Alan and Sarah Rowe praised the efforts of the Department's students. "We couldn't run this event without them. It's hard work, they don't have to do it - yet they are full of enthusiasm, which rubs off on the children they talk to."

Further details of the Department's outreach activities are available at: www.eng.cam.ac.uk/outreach

Engineering students display their design skills

Manufacturing Engineering students held their 2006 Design Show, displaying a range of new products that they have developed as part of their course.

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.

This year's projects included an innovative mobile accident screen to discourage 'rubbernecking' by passing motorists and a glove that uses ultrasound to help the partially sighted 'sense' their surroundings.

"The students have been working on their projects for most of the past year and the results are fantastic," said Lecturer Dr James Moultrie. "Some ideas have real commercial potential and they will be seeking finance to take them further."

"These projects demonstrate how important it is for engineers to develop their design skills," said Dr Moultrie. "It's not just about mastering the technology and science - engineers also need to think about their products from a user's perspective and design things that are both attractive and easy to use - and that fill a real need. Good design, in its widest sense, plays a vital part in turning technology into exciting and successful products."

Touchsight: helping the visually impaired 'sense' their surroundings

Axi-Shield: the accident screen that puts a stop to rubbernecking

The projects

Ten teams of four students each spent many months researching the market, designing and testing their product and preparing a business plan. Four of the projects this year were:

Touchsight: helping the visually impaired 'sense' their surroundings

"Our team set out with the aim of providing the visually impaired with confidence in the real world. Along the way we came to understand the difficulties faced by visually impaired people during their daily lives," said Samaan Rahman, one of the four members of the Touchsight team.

Products with electronic sensing systems for the blind do exist but very few have achieved widespread popular appeal and most are instantly noticeable and potentially stigmatise the user. The students came up with a revolutionary glove-based system, which combines ultra-sound with sensory feedback. The product is unobtrusive and enables the user to 'sense' their immediate surroundings. Trials with blind users have resulted in extremely positive feedback and a demand for the product to be taken all the way to market. "Analysis carried out by the team has shown the product to be technically feasible as well as financially viable," said Samaan. "Furthermore, from the invaluable feedback given by user groups, we are confident that we have a product with the potential to improve the quality of life for many people."

Axi-Shield: the accident screen that puts a stop to rubbernecking

Axi-Shield is a versatile mobile accident screen capable of fast and safe deployment on major roads, to reduce the likelihood of secondary accidents caused by 'rubbernecking'. The students behind it say it could be deployed from a standard transit van in under five minutes to provide rapid protection around an accident scene. Rubbernecking costs an estimated £27m

Snowshell: intelligent snowboard protection

MyMax: 3D movies from a standard projector

annually in the UK, through time lost and through further accidents resulting in secondary fatalities. The UK Highways Agency has been trialling a system developed in the Netherlands. Early evidence indicates a cheaper more flexible solution is needed which can be rapidly deployed. Axi-Shield addresses this gap and the student team believes it represents the most advanced mobile anti-traffic screen in the world.

Snowshell: intelligent snowboard protection

The Snowshell arm guard has been designed from first principles, based around a thorough understanding of how the arm behaves during a fall. There are an estimated 450,000 serious injuries globally as a result of snowboarding accidents. Over 45% of these are injuries to the arms. Although there are a large number of wrist and arm guards on the market, users complain that they are unappealing, uncomfortable and do not provide real protection in a major fall. The Snowshell arm guard aims to address all of these concerns, providing a carefully engineered solution that prevents the arm 'locking-out' during a fall, as well as providing wrist support and impact protection.

MyMax: 3D movies from a standard projector

There are a growing number of movies being produced in 3D formats, but which can only be watched using expensive and high-tech equipment. The MyMax system is an optical device which, when added to the front of a standard projector, enables these films to be viewed in all their 3D glory. This simple solution makes 3D cinema in the home a reality. "Developing MyMAX was a technical and business challenge, particularly as we were all too aware that the market for such a product is time-limited," said team member Sarah Edmund. "Overall we are very happy with the outcome, both in the way we managed to work as a team and to get MyMAX itself to work!"

Manufacturing Engineering is an option for undergraduates in their third and fourth years of a four-year engineering degree. It is taught in the Institute for Manufacturing, a part of the Department of Engineering.

Design forms an important part of the course, with a team-based project that runs throughout the student's third year. Students apply design and engineering skills to develop solutions to real problems. The teams create working technologies accompanied by a detailed business plan, addressing how their products will be taken to market.

Cambridge manufacturing students are much sought-after for demanding jobs, not only in manufacturing industry but also in other branches of engineering, consultancy or commerce and a whole range of unrelated fields. Students are well placed to start their own companies and many have gone on to do so.

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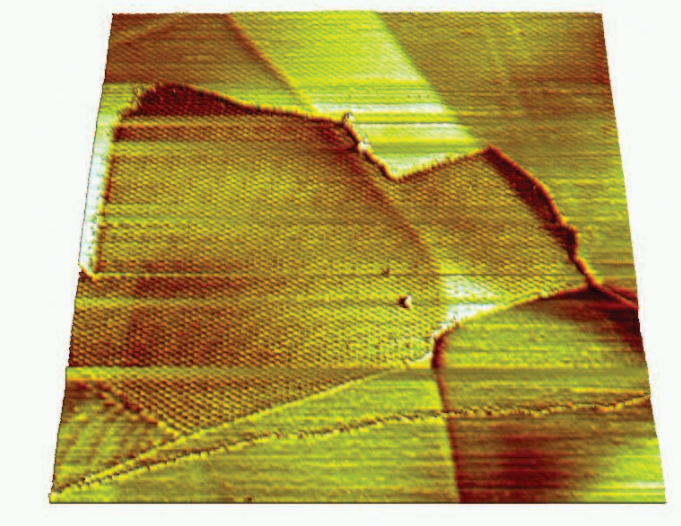
The Journal of Physics list their leading articles of 2005

An article by Dr Colm Durkan and Wing-Tat Pong from the Department's Nanoscale Science Laboratory has been selected as one of the leading articles published in the Journal of Physics in 2005.

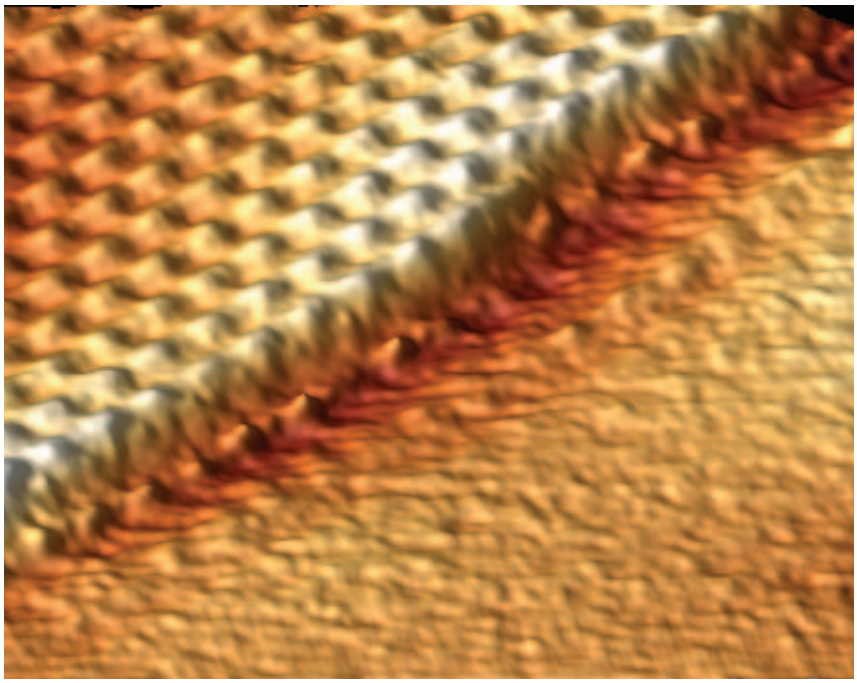
For the second year running, a special collection of articles, that highlight the very best research published in the Journal of Physics, have been selected for their presentation of outstanding new research, valuable reviews of the field, the highest praise from international referees, and the highest number of downloads from the journal's website.

The article is entitled 'A review and outlook for an anomaly of scanning tunnelling microscopy (STM): superlattices on graphite' can be found at the link below. Since its invention in 1981, scanning tunnelling microscopy (STM) is well-known for its supreme imaging resolution enabling one to observe atomic-scale structures, which has led to the flourishing of nanoscience. As successful as it is, there still remain phenomena which are observed using STM but are beyond our understanding. Graphite is one of the surfaces which have been most extensively studied using STM. However, there are a number of unusual properties of graphite surfaces. First reported in the 1980s, superlattices on graphite have since been observed many times and by many groups, but as yet our understanding of this phenomenon is quite limited.

The collection of articles contains 25 papers and topical reviews and provides a taste of the content published in the journal, the full list can be viewed at the Journal of Physics website http://journals.iop.org/



Layers of graphite overlap giving a superlattice structure. Image size is 500nm (nanometres) x 500nm



Layers of graphite overlap giving a superlattice structure, around 100nm x 100nm, the height scale is around 0.6nm.

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