DEPARTMENT OF ENGINEERING

NEWS

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Dambusters: Building The Bouncing Bomb
Annual Carl Zeiss Photography and Video Competition Winners
Cambridge Manufacturing Engineering Design Show 2011
Eco House Initiative

UNIVERSITY OF CAMBRIDGE

In this issue

Cover photo: Hugh Hunt in the cockpit of a Lancaster Bomber while filming *Dambusters: Building the Bouncing Bomb*, see page 10 for the full article. Photo courtesy of Windfall Films.

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Building our alumni community – your chance to shape the future

This newsletter showcases recent news stories from across the Department.

We see examples of individual brilliance and success together with an ever increasing number of multidisciplinary team efforts that grapple with some of the toughest challenges in the world. We are telling these stories to a widening audience, engaging the support of the University and gaining increasing attention through our website, Youtube channel, and Flickr site. Our aim is not only to build a stronger profile for the Department, but to help Engineering as a whole. We have achieved some notable successes, for instance: Daniel Wolpert's TED talk has been viewed over 500,000 times online; and Hugh Hunt's Dambusters documentary won a global audience measured in millions picking up a Royal Television Society award for the best history programme of 2011.

If our world-class department can work more closely with its 17000 alumni, then there are few limits to what more we may achieve for engineering in the future. Recently, we have decided to develop the student-run Cambridge University Engineering Society (CUES) to create a life-long connection with our alumni*. We are making plans for the CUES, events, and connections with the University's new Facebook and LinkedIn sites. For this we need your input, so we would greatly appreciate responses to the questionnaire that can be found at the web address below.

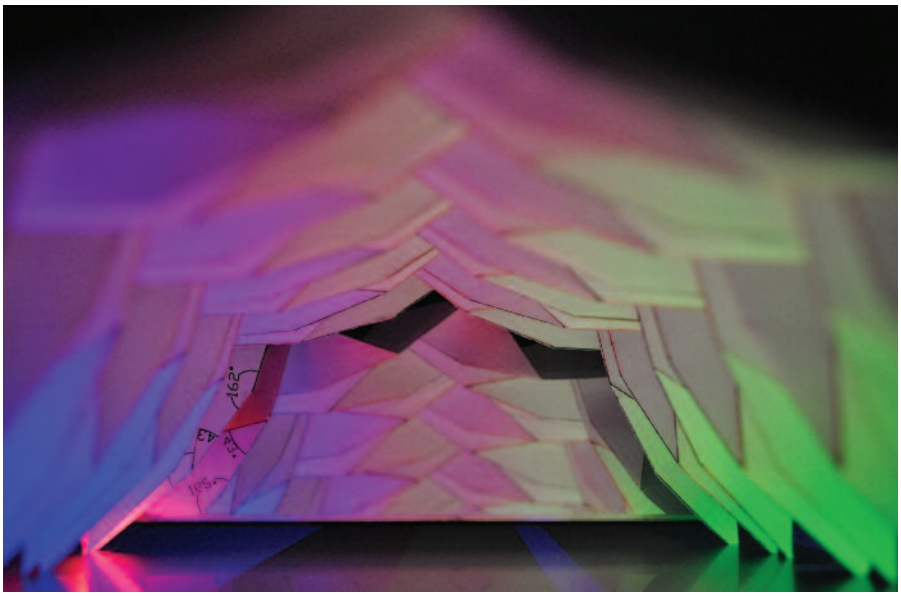
The 2012 Engineering alumni questionnaire can be found at:

https://surveys.eng.cam.ac.uk/alumni

You'll need to enter:
Username: alumni-user
Password: alumsurv2012

If you would prefer to complete a paper copy of the questionnaire please call: 01223 748217 or email: director-of-research@eng.cam.ac.uk

* The CUES is an extremely successful organisation run by undergraduates which focuses on helping students during their time at Cambridge. The Cambridge University Engineering Association (CUEA) has quietly done great work with alumni over the years. The CUEA will now work with the CUES to connect alumni throughout their careers and beyond. The CUEA name will fade into the background; the CUES name will come to the fore.



Flat-foldable Paper Tunnel by Pooya Sareh. One of the photos entered into the Carl Zeiss photography competition, see page 12 for full article. Pooya studies generalised versions of the Miura pattern, and has developed a family of 'Flat-foldable' structures which can be used as conceptual designs for future engineering structures.

An integrated engineering department founded on core strengths spanning all engineering disciplines and also cross-connected by four strategic themes:
- **Energy, transport and urban infrastructure**
- **Uncertainty, risk and resilience**
- **Engineering for life sciences**
- **Inspiring engineering through industrial collaborations.**

Professor Mark Welland knighted and receives two distinguished awards from the US government

Professor Sir Mark Welland, Director of the Department's Nanoscience Centre and Chief Scientific Adviser to the Ministry of Defence, has been awarded a knighthood in the Queen's Birthday Honours list 2011.

HAN HUTTON, CPSL

On learning of the knighthood he said: "I feel deeply honoured. It has been a real privilege over the past 25 years to work with the exceptional students, researchers, staff and academics that make Cambridge so special. Over the past three years in Government I feel privileged to have worked with civilian and military colleagues to support UK Defence and Security."

In addition, Sir Mark was awarded prestigious honours by the US Department of Defense and the US Department of Energy.

The first US award, the 'Office of the Secretary of Defense Medal for Exceptional Public Service', is the highest level non-career award given by the Secretary of Defense. It was awarded to Professor Welland for his 'exceptional public service' and highlights his many contributions to anti-proliferation. The citation commends Professor Welland, stating: Professor Welland's numerous accomplishments had a significant impact on the United States' and the United Kingdom's national security. He provided the vision necessary to align the program of atomic weapons cooperation between our two countries. He greatly expanded mutual participation of scientists and engineers in directed stockpile work; fostered bilateral cooperation in nuclear, chemical, and biological threat reduction; led new efforts in the area of treaty monitoring and verification; and advocated for the expanded trilateral threat reduction cooperation with France. His vision, leadership, foresight, and direction had far-reaching and positive impacts in several areas: The United States and the United Kingdom atomic weapons cooperation; several international engagement programs such as the Global Initiative to Combat Nuclear Terrorism and the North Atlantic Treaty Organization-Russia Council; the entire field of bilateral work to counter weapons of mass destruction; and the United States and the United Kingdom relations writ large. The distinguished achievements of Professor Sir Mark Welland reflect great credit upon himself and the Department of Defense. Professor Welland was also presented with an award by the US National Nuclear Security Administration (NNSA), part of the US Department of Energy, which is rarely bestowed upon non-US citizens. He was given the 'The NNSA Gold Medal' for his 'outstanding leadership and wise counsel as Chief Scientific Advisor to the United Kingdom'. The citation highlights his contributions to national security, stating 'Our countries are stronger and safer for your service.'

Professor Welland was on secondment to the Ministry of Defence 2008-2011 as Chief Scientific Adviser, where he directed the science and technology programme, chaired the Investment Approvals Board that authorises all major capital procurement projects and acted as the Principal of the 1958 Mutual Defence Agreement between the US and the UK on nuclear matters.

Professor Welland started his career in nanoscience and nanotechnology at IBM Research Laboratories, Yorktown Heights, USA, where he was part of the team that developed one of the first scanning tunnelling microscopes. Upon moving to Cambridge in 1985 he set up the first tunnelling microscopy group in the UK and in 1991 he began the nanoscience research group. He established a purpose-built facility at the University, the Nanoscience Centre, which undertakes a variety of nano-related research programmes of an interdisciplinary nature. This was the base for the Interdisciplinary Research Collaboration (IRC) in Nanotechnology of which Professor Welland was the Director and whose highly successful legacy has been far reaching.

Professor Welland has made many contributions and been recognised at an international level and leads the UK side of the World Premier International (WPI) Research Centre Initiative, a 200 million USD program sponsored by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) in Japan.

He established and co-directed the Science and Technology Research Centre at the American University in Cairo, Egypt from 2003 – 2011. In recognition of his work with India, Sir Mark was elected as a Foreign Fellow of the National Academy of Sciences India in 2008. In 2010 he was elected a fellow of the Royal Academy of Denmark.

In addition to his scientific work Professor Welland has been involved in a number of reports, national and international, dealing with the societal, ethical and environmental issues of nanotechnology and was a member of the Royal Society/Royal Academy of Engineering Nanotechnology Study Working Group that reported to the UK Government in July 2004.

Professor Dame Ann Dowling winner of the UKRC's Women of Outstanding Achievement awards

Professor Dame Ann Dowling was among seven women at the forefront of science, engineering and technology who were honoured at the Royal Academy of Engineering in London.

COURTESY OF ROBERT TAYLOR PHOTOGRAPHY AND THE UKRC

Professor Dowling was a winner in the UKRC's Women of Outstanding Achievement awards, which recognise women who are "an inspiration to others".

The UKRC is the UK's lead organisation for the provision of advice, services and policy consultation regarding the under-representation of women in science, engineering, technology and the built environment.

Professor Dowling, Head of the Department of Engineering, received the Inspiration and Leadership in Academia and Research Award.

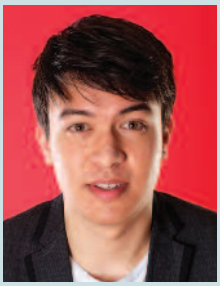
The winners were chosen by a panel of judges, chaired by Lord Willis of Knaresborough, who said: "The range and quality of nominations this year was exceptional, demonstrating the breadth of women's contribution and impact across all areas of science, engineering and technology."

A key part of the awards is the unveiling of the seven winners' photographic portraits. To view an online slideshow of the portraits visit: www.guardian.co.uk/science/gallery/2011/may/06/women-outstanding-achievement-awards-2011

More information on Professor Dowling's achievements can be found on the UKRC website: http://theukrc.org/women/women-of-outstanding-achievement/the- winners-2011/professor-dame-ann-dowling

Engineering student on 'The Rob Brydon Show'

Department of Engineering and King's College student Phil Wang demonstrated his comedic talents on BBC2's 'The Rob Brydon Show' (first shown on Friday 19 August 2011).



Twenty-one year old Phil appeared alongside guests Dame Edna Everage and Will Young. His five minute stand-up routine was well received by the studio audience.

Phil's appearance on the show was arranged by his agent at the Avalon Management Group. He was signed to the agency after winning the 2010 Chortle Student Comedian of the Year Award. Phil is also the current President of the world-famous Cambridge Footlights (Cambridge University Footlights Dramatic Club).This long-standing institution has in the past helped nurture such talents as John Cleese, Emma Thompson, Stephen Fry and Hugh Laurie.

As well as forging a name for himself in the world of comedy, Phil has successfully completed his first three years of study at the Department of Engineering. In October he started his 4th year project 'Dynamics and Control in Formula 1' in the Information Engineering Division.

Phil commented on how he manages to find time to study as well as write and perform:

"Not very well. Aside from a few vexing exceptions, it is near impossible at Cambridge to pursue more than one thing at a high level to the best of your abilities. There's a balance I am constantly having to strike between studying engineering and comedy. For instance, engineering deadlines sometimes mean I have to miss a show or rehearsal, and the comedy has meant that I keep missing out on the firsts I'd obviously otherwise be getting every year."

Phil performed in 'The Comedy Zone' at the Edinburgh Fringe Festival and is also involved in 'The Life Doctor', a show that he has co-written and co-directed with Adam Lawrence.

When asked which career path he thinks he will be following this time next year – will it be engineering, or will it be comedy?

"At the moment it looks like it will be comedy. However, engineering is a noble (and EMPLOYABLE) degree to have. I also find it quite interesting most of the time, which helps."

Third year student exchange opportunities

In the year 2000, as a by-product of the Cambridge-MIT initiative, a twelve-month credit-bearing exchange scheme was initiated between the two universities. Up to twenty of our third-year students spend a year at MIT, and the same number of MIT students come to Cambridge.

The Department of Engineering has always participated enthusiastically and found that the benefits to the students and the course as a whole are more far-reaching than they had initially anticipated. Most students benefit from the experience of two different world-class educational environments; some even find the experience 'life changing' as they rise to meet challenges they had previously not imagined. The institutional benefits began to be evident when students returned to their home universities to take the fourth and final year of their course. They brought with them ideas from their year away.

They founded 'Project Expo' as an opportunity to show off Master's projects and other independent work. They ran focus groups to help us improve the course. They made a major contribution to the growth of independent student projects such as Eco-Racing, Spaceflight, the Autonomous Underwater Vehicle project and Full Blue Racing. Overall, the exchange had a much broader impact than the proportion of students actually involved in travelling to MIT.

In 2008 the Department of Engineering therefore decided to build on the success of the exchange relationship with MIT and set up a similar scheme with École Centrale Paris. The new French scheme was on a smaller scale to the American one with only two students travelling in each direction each year. In 2010 we added another two-student exchange, this time with the National University of Singapore and in 2012 we will extend it again to allow students to spend a year at the Technical University of Munich. We are most fortunate that the very best Universities in the world are keen to build a relationship with us in this way.

We strive to ensure that students are not left out of pocket by taking part. The two European exchanges are funded by the Erasmus programme of the European Union. In addition the French exchange is supported by Schlumberger and the French Embassy in London. The exchange with the National University of Singapore has been funded by Shell UK from 2010 to 2013, but we are presently looking for a new sponsor to take this over from 2013 onwards. BP are the sole sponsors of the fifteen Engineering places on the Cambridge-MIT Exchange Scheme.

As an international engineering department, we feel it is right to maintain an international dimension in our education as well as in our research. Compared to many other European universities our level of exchange activity is relatively low. But compared to other departments in Cambridge we are unique in running exchanges at all. This creates an interesting tension that we address by aiming for quality rather than quantity in our exchanges. Our exchange schemes provide a strong link with key peer institutions around the world; they add an important dimension to the third year of our course, and produce students of unparalleled maturity, breadth and scholarly accomplishment. We look forward to welcoming our first exchange students from Munich in October and to the continued development of this important activity in the future.

Technical University of Munich

Massachutsetts Institute of Technology

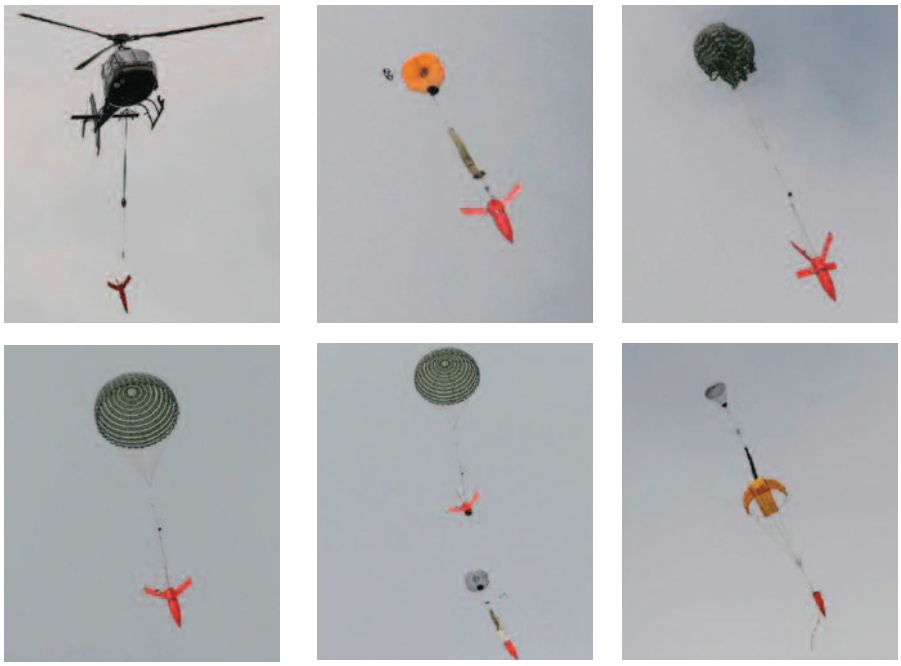
École Centrale Paris

National University of Singapore

Cambridge University Spaceflight student society tests parachutes for the ExoMars lander

Q: How do you test a parachute designed to enter a planet's atmosphere at high speed?

A: By entering a planet's atmosphere at high speed.



This sequence of photos is taken from a subsystem test to verify that all the parachutes deploy correctly. The vehicle was flown to 1000ft altitude under a helicopter, before the sequence was initiated by an encrypted radio command. After falling for 3 seconds, the cap at the back of the vehicle is ejected, and the orange pilot parachute pulls the test parachute out of its packing bag. A few seconds later, the nosecone is released, and the yellow backup parachute is deployed. The two halves land separately to give softer landings. In the real test at the edge of space, the yellow backup parachute can be used to save the mission if something goes wrong with the test parachute.

In conjunction with the European Space Agency (ESA), students from the Cambridge University Spaceflight team have recently tested parachutes for the ExoMars lander, a European-led robotic mission to Mars currently under development by NASA and the ESA, by re-entering Earth's atmosphere at 450mph.

'Six Minutes of Terror' is how engineers describe the process of Entry, Descent, and Landing (EDL) on Mars. It is perhaps the most challenging part of any Mars lander mission, a complex ballet of heat shields, parachutes, retro-rockets and airbags, all having to assemble themselves mid-air; a failure in any one part would lead to almost certain mission failure. Simulating this is no easy task: a parachute is a complex, fabric structure opening into a fluid flow and so real hardware testing is essential. However, Mars has an atmosphere more than one hundred times thinner than Earth's, and re-creating these high velocity, low density flows in a wind tunnel is a hugely expensive, if not impossible, task. The Spaceflight team's testing method has not only been successful but is an extremely cost effective way to test parachutes in a Mars-like environment.

Using their experience with high altitude scientific balloons and instrumentation, the CU Spaceflight team built a balloon-lofted vehicle, packed with a test parachute. This was taken to the top of the atmosphere, where the air is a similar density to the surface of Mars. They then instructed the vehicle to free-fall for an amount of time calculated to let it accelerate to Mach 0.8 (80% of the speed of sound), where it deployed the parachute, and monitored its inflation using a suite of instrumentation including accelerometers, gyroscopes and a high-speed camera.

A slow motion video at www.eng.cam.ac.uk/news/stories/2011/CU_Spaceflight shows the parachute dynamics during one of the low-speed system development tests. At 24km, the vehicle cuts away from the balloon, and a rope from the balloon immediately pulls the parachute out of the deployment bag. Because the vehicle is going so slowly, and the air is so thin, the parachute takes a few seconds to inflate (the video is 10x slower than real-life) and the vehicle tumbles. In the high-speed parachute test, the parachute was deployed at Mach 0.8 and was fully inflated in 1/20th of a second.

The team recently presented their work at the 21st AIAA Aerodynamic Decelerator Systems Conference in Dublin, where it took first place in the Best Student Paper competition.

The paper can be downloaded at: www.cuspaceflight.co.uk/CUSF_AIAA_2011.pdf
Cambridge University Spaceflight is a student-run society formed in 2006 to experiment with low-cost spaceflight www.cuspaceflight.co.uk

'Endeavour' blazes across the Outback

The Cambridge University Eco Racing Team (CUER) has completed the 2011 Veolia World Solar Challenge.

The car, named 'Endeavour Mk II', successfully battled bush fires and thunderstorms to complete the gruelling 3,000 km race across the Australian Outback, from Darwin to Adelaide.

The CUER team was entering the race for only the second time and the car and team outperformed the other British entrant (Durham University) and performed at a similar level to some of the most recognised teams in the world.

The race this year suffered from poor weather conditions that meant 30 out of 37 entrants in the field (CUER included) were unable to travel the entire race distance under solar power alone. Endeavour II was only able to complete just under half the race under solar power in the strict 6-day time limit.

The team was able to demonstrate levels of technical reliability and organisational competence that were significantly better than both their predecessors in 2009 and many of their fellow competitors. Furthermore, the professionalism of CUER was recognised by the event organisers who presented them with the award for the team that has displayed the highest standard of safe and consistent racing.

CUER is a team composed entirely of students from the University of Cambridge who, in their spare time, design and build solar and electric powered racing vehicles. Over the past 18 months, the team estimates that around 17,000 man-hours have been poured into the car, which is the culmination of a number of Masters projects in Cambridge University's Engineering Department.

Work has already begun on development of a much improved car to enter the World Solar Challenge in 2013 and the team are looking to use their entrepreneurial skills to secure support for its efforts over the next two years.

The CUER website: www.cuer.co.uk

Amantys secures $7 million in funding

Amantys Limited, a start-up based on research from the University of Cambridge, has recently secured $7 million in Series A funding to continue with the commercial development of its digital power platform.

The new funding round has been led by Moonray Investors, part of Fidelity International, and ARM Holdings plc (ARM). Moonray has additionally purchased the remaining external minority interests in Amantys.

Dr Patrick Palmer, Reader in Electrical Engineering at the Department of Engineering, developed technology that will simplify the design of medium voltage power electronic equipment using insulated gate bipolar transistors (IGBTs).

Dr Palmer and his former student co-inventors have been supported by Cambridge Enterprise Limited, the University's commercialisation group, in their efforts to see the results of their basic research exploited commercially. The company was founded in 2010 by a number of former ARM executives and Dr Palmer, who remains the company's Chief Scientist following this round of investment.

Power conversion occurs everywhere in the modern world. It keeps the online world connected; it controls motors small and large, from trains and planes to the cars we ride in; to solar panels and UPS power supplies.

However, as energy flows from power stations through power lines and transformers to consumers, energy is wasted. Amantys is developing innovative and disruptive power control products to address this wastage.

Amantys' technology allows power transistors to be configured more easily to construct systems to switch medium and high voltages. This allows the designer to continue to use existing design topologies to build medium voltage inverters with higher efficiency and without the need to move to more complicated systems. Products which use Amantys' technology will benefit from greater efficiency, improved reliability, ease of design and reduced cost.

James Dyson design award

Department graduate, Michael Korn, is the UK winner of the James Dyson Award – an international design competition run across 18 countries.

Michael won the award – and a prize of £1,000 – for his product KwickScreen, a portable room divider, designed principally for use in hospitals to isolate infected patients, as well as give them more dignity and privacy.

The screens enable hospitals to make more effective use of their accommodation as infected patients do not need to be moved into a private room. "In hospitals, there is a huge opportunity to optimise the use of bedstock and overall productivity whilst also improving the patient care environment," said Michael.

The 2m high, bendable screens can be pulled out to anything up to 3.5m wide and retract back into a compact vertical compartment. They use a technology, the RolaTube, invented with NASA for use in space.

Michael gained inspiration from nature, including a frog's tongue, to design the retractable KwickScreens. "I was interested in the way a frog's tongue rolls out, which led me to prototyping with children's slap-on bracelets and tape measures, which then led me to RolaTube – a materials technology company affiliated with the Department of Engineering."

Michael used what he learned as a student on the Department's Institute for Manufacturing's Manufacturing Engineering Tripos (MET) course to help him to develop his product. "MET gave me a broad understanding of business and the importance of appropriate management strategies – combined with a grounding in technology and engineering. This prepared me perfectly for a future in design, manufacture and entrepreneurship."

Michael was also a runner up in the overall James Dyson Award competition (winning a further £2K) and in addition has won the title of Shell LiveWIRE Young Entrepreneur of the Year 2011 and £10,000 for his invention.

Further information about KwickScreen: www.kwickscreen.com

Communications technologies

Study shows some families have taken steps to avoid feeling overwhelmed by communications technologies

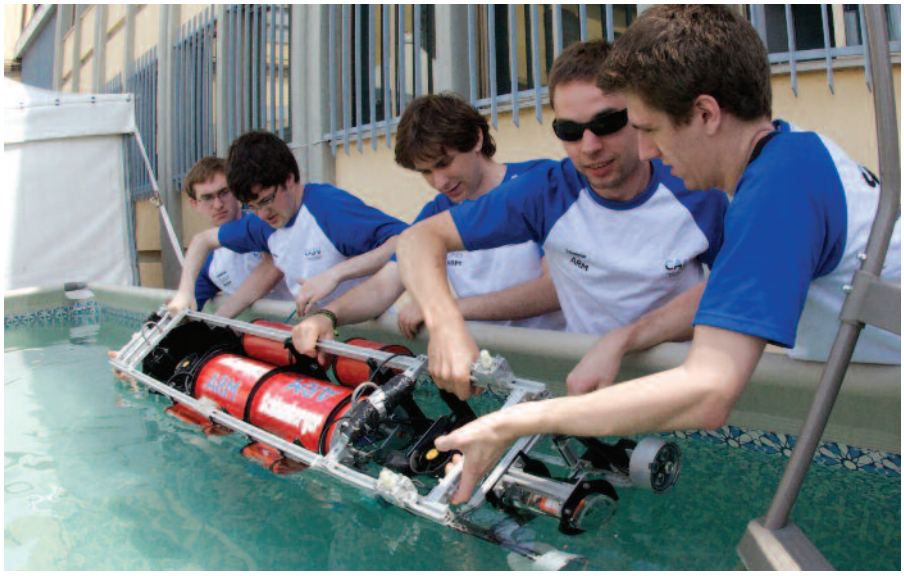
An international study, led by Anna Mieczakowski, Tanya Goldhaber and Professor John Clarkson at the Engineering Design Centre (EDC) here at the Department of Engineering, has found that one in three people in the UK has felt overwhelmed by communications technologies, including texting, email and social networking, to the point that they feel they need to escape them. However, some simple steps have been identified to help improve well-being and to avoid technology overwhelming family life according to the BT-sponsored study.

The survey of 1,269 people and in-depth interviews with families in the UK revealed that those people who have frequently felt overwhelmed are also more likely to feel less satisfied with their life as a whole. Conversely, those who felt in control of their use of communications technology were more likely to report higher levels of overall life satisfaction. The study has used the findings to introduce a 'five-a-day' Balanced Communications Diet to help families get the most out of communications.

More information can be found at: www-edc.eng.cam.ac.uk/projects/comms/

Students' teamwork rewarded

Cambridge Autonomous Underwater Vehicle (CAUV) is an undergraduate-led project based in the Department of Engineering.



The team lowers Red Herring into the salt-water ballasting tank provided by the Nato underwater research centre in Italy.

The CAUV develop and operate AUVs – robotic submarines – for scientific research, with the goal that they should be small, modular and relatively low cost. The team enters the Student Autonomous Underwater Challenge – Europe (SAUC-E) every year. This provides some short term targets and an opportunity to exchange ideas with other universities.

SAUC-E attempts to stimulate progress in the areas of underwater technology and autonomy by challenging students to complete a series of missions based on activities that AUVs could be used for commercially. The tasks change from year to year, with no two courses being the same. This year the tasks included inspecting a pipe, surveying a wall, circling and then freeing a tethered buoy and tracking a surface vehicle as it moves around the arena. During a competition run the vehicle is not allowed to communicate with anything external, and tasks must be done consecutively without breaking the surface.

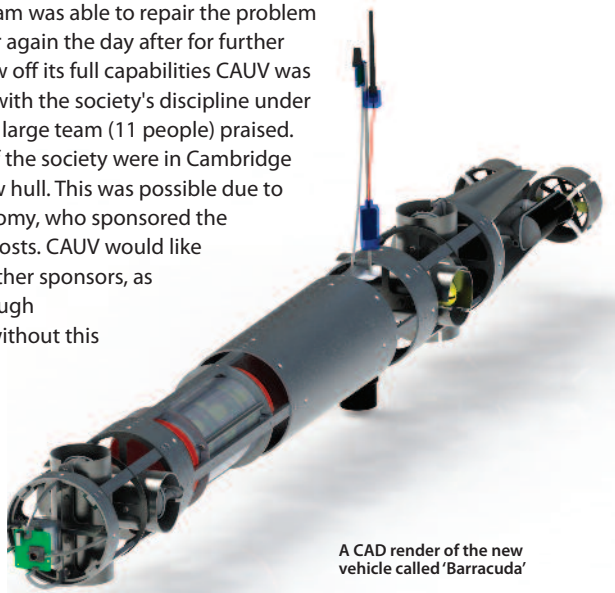
CAUV entered SAUC-E for the 5th year with their current vehicle, 'Red Herring'. It is a large, simple, robust vehicle, designed to be used as a software development platform while a highly integrated, user oriented vehicle is designed, manufactured and tested over a two year period. This was the second year Red Herring had been entered in SAUC-E, with the new hull due to compete in 2012.

The CAUV team performed strongly all week, with Red Herring the first vehicle to enter the main harbour. The team was able to put to sea every day, a substantial improvement in availability over last year which resulted in the completion of a lot of very valuable software testing and data recording. They qualified for the semi-finals and looked on-course to progress to the final when unfortunately technical difficulties struck and they were unable to record a semi-final run.

Despite this frustration the team was able to repair the problem and Red Herring took to the water again the day after for further testing. Although not able to show off its full capabilities CAUV was awarded the prize for teamwork, with the society's discipline under stress and co-ordination of such a large team (11 people) praised.

Last summer, five members of the society were in Cambridge working on the design for the new hull. This was possible due to the generosity of ARM and Autonomy, who sponsored the students to cover the associated costs. CAUV would like to thank them, along with all its other sponsors, as the society is funded entirely through sponsorship and could not exist without this support.

The Cambridge Autonomous Underwater Vehicle website: www.cambridgeauv.co.uk



A CAD render of the new vehicle called 'Barracuda'

International Karl-Kolle Prize for metal forming

Omer Music a fourth-year PhD student in the Department's Low Carbon Materials Processing group has won the first International Karl-Kolle Prize for Metal Forming.

The prize, awarded by the German Metal Forming Association (Arbeitsgemeinschaft Umformtechnik) is presented to young researchers in recognition of their "application oriented innovative outstanding research achievements in the field of metal forming" and aims to support young researchers in their career.

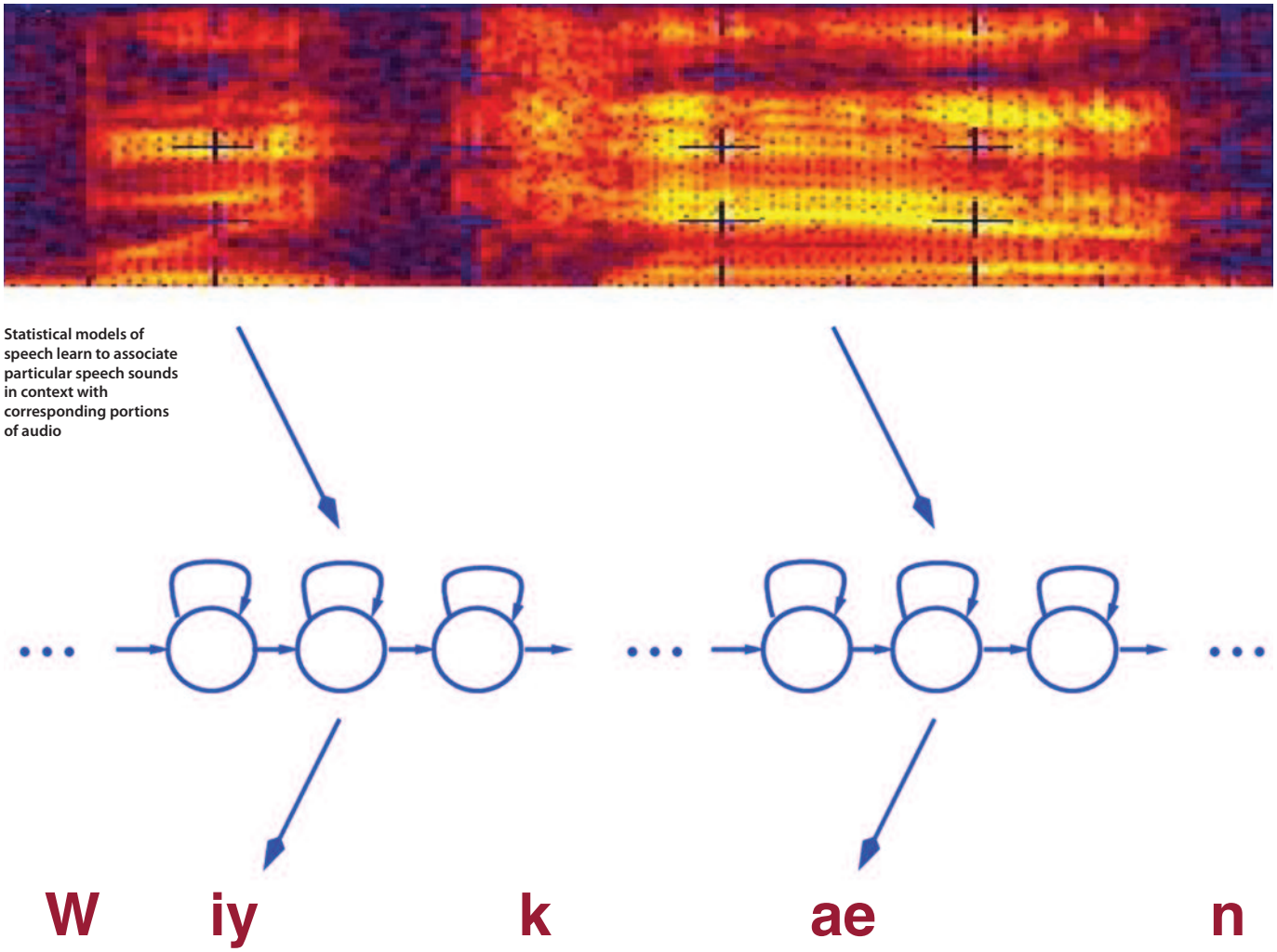
Omer's research has focused on flexible sheet metal forming. This can broadly be defined as shaping metal sheets using relatively simple tools under computer control. This approach avoids using specialised tools and allows production of low-volume, custom made components or prototypes. The main output of Omer's research has been the invention of a novel flexible forming process – Flexible Asymmetric Spinning. He has also designed a prototype machine for this process. Flexible Asymmetric Spinning is very similar to the art of pottery using a potter's wheel. It shapes sheet metal (instead of clay), using a set of computer-controlled rollers. To explore the process, a prototype machine has been built in the Department's workshops.

The award ceremony took place at the 10th International Conference on Technology of Plasticity, a major international conference on metal forming, which was held in Aachen, Germany.

Omer's PhD was supervised by Dr Julian Allwood

Smart listeners and smooth talkers

Human-like performance in speech technology could be just around the corner, thanks to a new research project that links three UK universities.



Statistical models of speech learn to associate particular speech sounds in context with corresponding portions of audio

"To make the technology more usable and natural, and open up a wide range of new applications, requires field-changing research."
Professor Phil Woodland

Human conversation is rich and it's messy. When we communicate, we constantly adjust to those around us and to the environment we're in; we leave words out because the context provides meaning; we rush or hesitate, or change direction; we overlap with other speakers; and, crucially, we're expressive.

No wonder then that it's proved so challenging to build machines that interact with people naturally, with human-like performance and behaviour. Nevertheless, there have been remarkable advances in speech-to-text technologies and speech synthesizers over recent decades. Current devices speed up the transcription of dictation, add automatic captions to video clips, enable automated ticket booking and improve the quality of life for those requiring assistive technology.

However, today's speech technology is limited by its lack of ability to acquire knowledge about people or situations, to adapt, to learn from mistakes, to generalise and to sound naturally expressive. "To make the technology more usable and natural, and open up a wide range of new applications, requires field-changing research," explained Professor Phil Woodland of Cambridge's Department of Engineering.

Along with scientists at the Universities of Edinburgh and Sheffield, Professor Woodland and colleagues Drs Mark Gales and Bill Byrne have begun a five-year, £6.2 million project funded by the Engineering and Physical Sciences Research Council to provide the foundations of a new generation of speech technology.

Complex pattern matching

Speech technology systems are based on powerful techniques that are capable of learning statistical models known as Hidden Markov Models (HMMs). Trained on large quantities of real speech data, HMMs model the relationship between the basic speech sounds of a language and how these are realised in audio waveforms.

It's a complex undertaking. For speech recognition, the system must work with a continuous stream of acoustic data, with few or no pauses between individual words. To determine where each word stops and starts, HMMs attempt to match the pattern of

successive sounds (or phonemes) to the system's built-in dictionary, assigning a probability score as to which sounds are most likely to follow the first sound to complete a word. The system then takes into account the structure of the language and which word sequences are more likely than others.

Adapt, train and talk

A key focus for the new project is to build systems that are adaptive, enabling them to acclimatise automatically to particular speakers and learn from their mistakes. Ultimately, the new systems will be able to make sense of challenging audio clips, efficiently detecting who spoke what, when and how.

Unsupervised training is also crucial, as Professor Woodland explained: "Systems are currently pre-trained with the sort of data they are trying to recognise – so a dictation system is trained with dictation data – but this is a significant commercial barrier as each new application requires specific types of data. Our approach is to build systems that are trained on a very wide range of data types and enable detailed system adaptation to the particular situation of interest. To access and structure the data, without needing manual transcripts, we are developing approaches that allow the system to train itself from a large quantity of unlabelled speech data."

"One very interesting aspect of the work is that the fundamental HMMs are also generators of speech, and so the adaptive technology underlying speech recognition is also being applied to the development of personalised speech synthesis systems," added Professor Woodland. New systems will take into account expressiveness and intention in speech, enabling devices to be built that respond to an individual's voice, vocabulary, accent and expressions.

The three university teams have already made considerable contributions to the field and many techniques used in current speech recognition systems were developed by the engineers involved in the new project. The new programme grant enables them to take a wider vision and to work with companies that are interested in how speech technology could transform our lives at home and at work. Applications already planned include a personalised voice-controlled device to help the elderly to interact with control systems in the home, and a portable device to enable users to create a searchable text version of any audio they encounter in their everyday lives.

For more information please contact: Phil Woodland, Professor of Information Engineering, email: pcw@eng.cam.ac.uk

Sir William Hawthorne, MA, ScD, CBE, FRS, FREng
22 May 1913 – 16 September 2011

Professor Sir William Hawthorne, former Head of the Department of Engineering and Master of Churchill College, died on Friday 16th September aged 98. He played a crucial role in the team that developed the gas turbine jet engine in Britain during the Second World War.

JULIA HEDGECOE

Sir William was a popular Master of Churchill College (1968-1983).

Sir William read Mathematics and Mechanical Sciences at Trinity College, graduating in 1934. He spent two years as a graduate apprentice with Babcock and Wilcox Ltd, before going to MIT to do research on laminar and turbulent flames.

He returned to the UK in 1940 and joined the Royal Aircraft Establishment at Farnborough. He was seconded from there to Power Jets Ltd, the company founded by Frank Whittle to develop the world's first operational jet engines. He worked with Frank Whittle on combustion chamber development for the jet engine. He was appointed George Westinghouse Professor of Mechanical Engineering at MIT at the age of 35.

In 1951 he returned to Cambridge to be elected a Fellow of Trinity and take up the newly-created Hopkinson and ICI chair in Applied Thermodynamics. Here he developed teaching and research facilities in engineering thermodynamics and continued his research on the theory of flow in compressors and turbines.

His most important work at Cambridge, however, was to improve the understanding of inefficiencies and loss of performance in turbomachinery, such as jet engines (or even wind turbines). During his time as head of the Department of Engineering, from 1968 to 1973, he and Professor Sir John Horlock established the Turbomachinery Laboratory.

In 1956 the oil shortage after the Suez Crisis led Sir William to develop an idea for using flexible tubes, made of rubberised cotton dinghy fabric, as oil barges, to be filled with oil and towed by existing tankers. The advantage of these plastic vessels, christened Dracones, was that they could be rolled up and returned quickly, even by air, to the source of supply.

Sir William was a Fellow of the Royal Society, a Founder Fellow of the Fellowship of Engineering, which subsequently became the Royal Academy of Engineering, and was knighted in 1970. He was active on many committees and advisory bodies concerned with energy matters and chaired the Advisory Council on Energy Conservation.

In 1939 he married Barbara Runkle. She died in 1992, and he is survived by their son and two daughters.

Dambusters: Building The Bouncing Bomb

The daring Dambusters raid of World War II, in which RAF pilots famously used a bouncing bomb to breach two German dams, has been recreated by a Cambridge-led team to prove how the amazing feat was achieved.

Simulated 'bouncing bombs' were constructed from scratch, then dropped by aircraft flying just 60 feet above the surface of a lake in British Columbia, Canada, to destroy a 130-feet wide dam. The project was led by Dr Hugh Hunt, from the Department of Engineering, University of Cambridge, and was the subject of a Channel 4 documentary *Dambusters: Building The Bouncing Bomb* aired in the UK in May 2011.

To date, nobody has examined the engineering complexity of the remarkable raid, which took place on the night of 16/17 May, 1943, or managed to prove how it was successfully carried out.

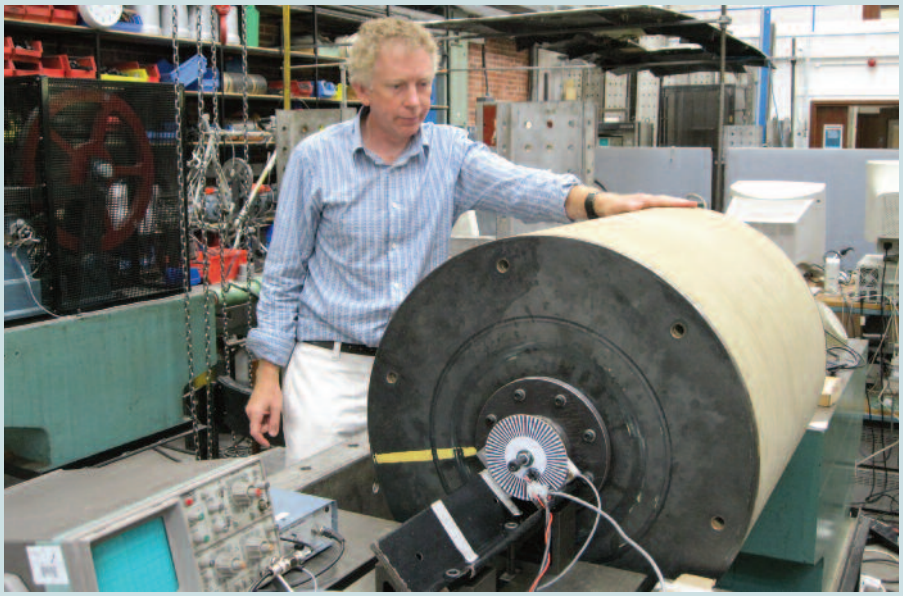
Originally known as 'Operation Chastise', and later immortalised in the 1955 film, The *Dam Busters*, the raid sent Lancaster bombers from RAF no. 617 squadron to fly dangerously low over reservoirs in the strategically important Ruhr Valley in order to bomb the Möhne and Edersee Dams. At the time, both were thought to be almost impregnable to conventional bombing raids.

Under intense anti-aircraft fire, the crews dropped 'bouncing bombs', specially designed by the British engineer, Sir Barnes Neville Wallis, to skip across the water en route to the target. If released at the right moment, these could bypass the torpedo nets the Germans had placed to defend the dam. On reaching the dam wall, they sank to a predetermined depth and exploded.

While the mission itself has gone down as one of the most iconic episodes in Britain's wartime story, few details about how the bouncing bomb was built remain. Most of Barnes Wallis' original calculations, designs and results were lost; many of them in a flood in the 1960s. The physics of 'ricochet' (the bouncing of objects on water) is quite well understood but actually doing it has been a different matter.

"There's no massive mystery in a theoretical sense, but the fact that no-one has been able to repeat the mission meant that there was no-one alive who knew whether it was difficult, easy, or indeed possible," Dr. Hunt said. "The question was really finding out whether anyone could do it again."

Drawing heavily on a 1976 paper by his Cambridge Engineering colleague, Professor Ian Hutchings, which proposed a model for how the bouncing bomb was made, Hunt set to work trying to build one. He started by firing cricket balls from a bowling machine at the Jesus Green open air swimming pool in Cambridge to test Hutchings' theories. This was gradually scaled up, until much larger imitation bombs were being fired out of a compressed air cannon.



Prototype bomb

Sitting on top of the dam

Bomb drop

Under intense anti-aircraft fire, the crews dropped "bouncing" bombs, specially designed by the British engineer, Sir Barnes Neville Wallis, to skip across the water en route to the target.

Cast and crew celebrate

The team of dam engineers, explosive experts, mechanics and pilots then headed for Mackenzie in British Columbia, Canada, where a 30-feet high and 130-feet wide dam was specially built to see if the Dambusters raid could be reconstructed.

Before that could happen, however, the group had to negotiate several engineering hurdles. A mechanism had to be designed to carry the bomb and the device itself had to be balanced so that it did not vibrate.

The biggest challenge was making the bomb itself spin. Barnes Wallis' original device bounced cleanly and was stabilised because it was rotating at a rate of 500 revolutions per minute (RPM) when it hit the water. For the reconstruction team, to do the same thing meant either repeating the inventor's strategy of spinning it during the flight – which is logistically complex – or setting it spinning on the runway before takeoff, which might lead to the RPMs falling too low before the aircraft reached the drop zone.

The group opted to set their bombs spinning before take off. To keep them turning, Hunt, who worked closely with his PhD student, Hilary Costello, designed a shield, rather like the windscreen on a vintage sports car. This was custom-designed to deflect air around one side of the device. The movement of the air kept the bomb spinning so effectively that it was still turning at 1,000 RPM when it was dropped.

The shield was developed and optimised with the aid of the Wind Tunnel in the aerodynamics laboratory in the Engineering Department here in Cambridge, primarily with a view to spoiling the aerodynamic lift due to spin (Magnus effect) so that there was no risk of the bomb rising up and hitting the plane on release. During these tests, the team found that a cut-down version of the shield helped significantly to keep the bomb spinning during flight.

Even then their problems were not over. During the first drop in Canada, the bombs were tangled up on release and the mission looked to be a failure. "It was one of those things," Hunt said. "The theory looks nice and easy , but once you do things for real, it's never that simple. There were a lot of glum faces."

Further inspection revealed that a release cable was five inches too short. This could not be lengthened, but two tie bars were replaced – each measuring 2.5 inches longer. On the next flight, the bomb bounced perfectly and after a few more test runs the dam was destroyed.

Not everything could be reconstructed faithfully. So few Lancaster bombers survive that the team had to use World War II vintage DC4 aircraft instead. The dam itself was also one third the scale of those attacked in Germany – although the rest of the project was scaled accordingly to make it realistic. For Hunt, however, this only served to emphasise the remarkable nature of what Barnes Wallis and the pilots of 617 squadron achieved. Of the 133 hand-picked air-crew in 1943, which comprised pilots of many nationalities, including members of the Canadian, Australian and New Zealand air forces, 53 lost their lives in the Dambusters raid.

"Our pilots had no-one shooting at them, the engineers could use things like bowling machines to test their theories, and the whole thing was only at one third scale – and even then it was hard enough," Hunt said. "You compare that with the original challenge – for Barnes Wallis and for the pilots – and you realise what an amazing achievement it was."

Hugh Hunt and Hilary Costello

Dambusters: Building the Bouncing Bomb **won the Royal Television Society best history programme 2011.**

Photographs courtesy of Windfall Films

Microscopic marvels and grand designs

The Department of Engineering's annual Carl Zeiss Photography and Video Competitions winning entries.

The annual contest invites professors, students and support staff to submit photos and videos associated with their day-to-day work.

First prize in this year's photo competition went to *Thin Film Solar Cell* by Erenn Ore, a second year PhD student in the Electronics, Power and Energy Conversion Group.

Taken using an optical microscope, the image shows a remarkably thin photovoltaic device made up of a series of films that are just a few nanometres thick. Researchers like Ore are trying to develop a model for producing these cells that could be taken to a mass market. If successful, this would drastically reduce the cost of solar cell production, which currently relies on more expensive silicon, wafer-based solar cells instead.

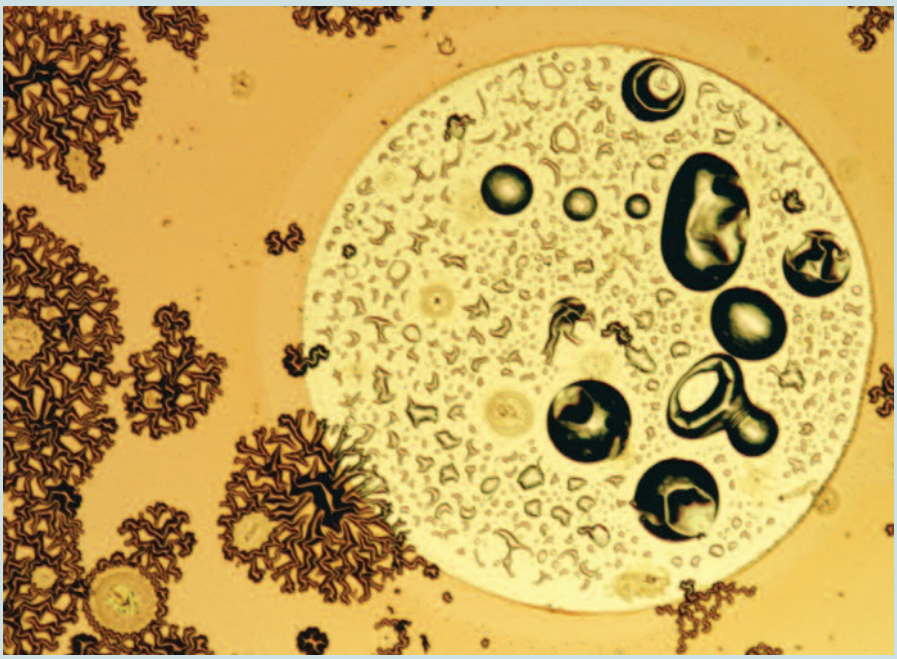
Other finalists in this year's competitions ranged from epic projects, realised on a grand scale, to those that require a microscope even to be seen.

In the photo category, *Long Day Testing* by James Crosby came second and shows the long hours that were put in during the development and testing of 'Red Herring', a prototype autonomous submarine that can be remotely controlled by humans (see article on p7). The intention is to create a robotic submarine that can be used for science and exploration, as well as more conventional tasks such as following underwater pipelines, locating buoys and navigating the environment using sonar.

Third prize went to *Cellular Adhesion of Human Osteoblasts to Ferromagnetic Stainless Steel* by Rose Spear. The fluorescent microscopic image shows osteoblasts – the cells responsible for bone formation – on ferromagnetic stainless steel. It was created during a project designed to shorten the time needed for new bone tissue growth, by using magnetic forces that act directly on the implant to strengthen the bone.

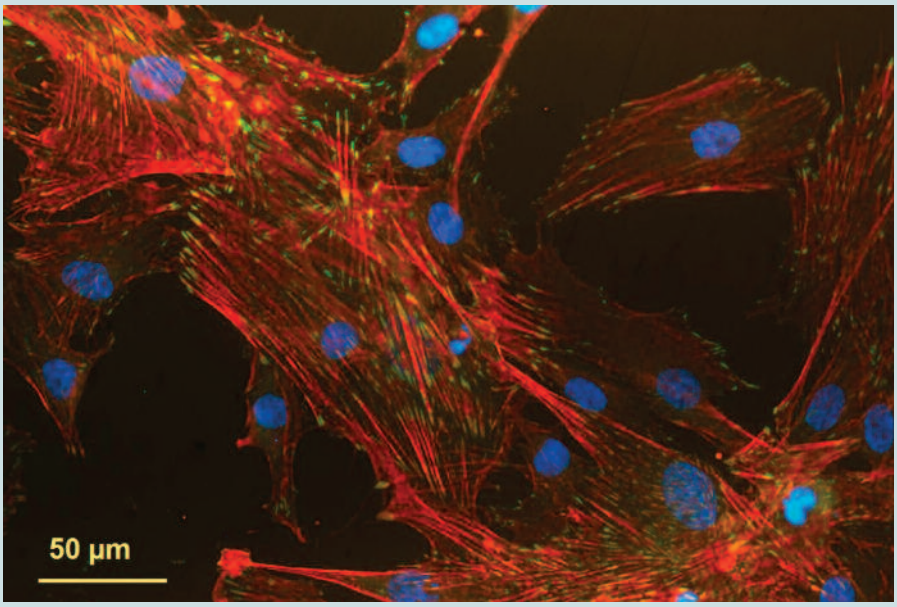
The engineering photo competition had more than 130 entries in total, with the subject matter covering themes as diverse as eco-friendly concrete, zinc oxide nanostructures, and projects on the London Crossrail site.

The full range of entries can be seen via the Department of Engineering's Flickr webpages: www.flickr.com/photos/cambridgeuniversity-engineering/sets/

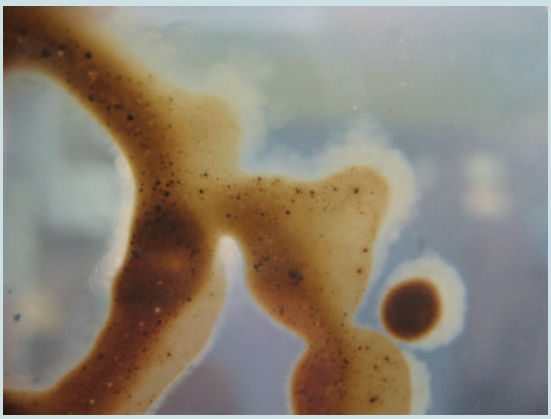


First prize, *Thin Film Solar Cell* by Erenn Ore

Second prize, *Long Day Testing* by James Crosby

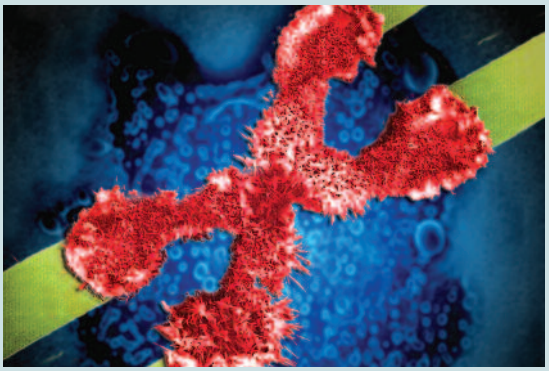


Third prize, *Cellular Adhesion of Human Osteoblasts to Ferromagnetic Stainless Steel* by Rosie Spear

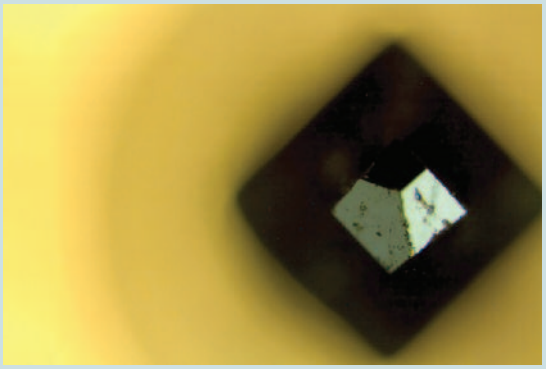


Here is a selection of other photographs from last year's Carl Zeiss Photography Competition

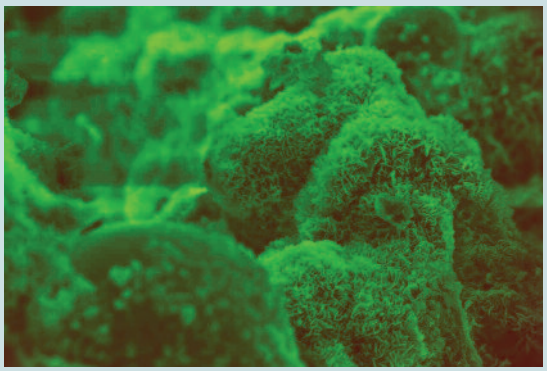
Marinobacter aquaeolei by Matthew Kuo



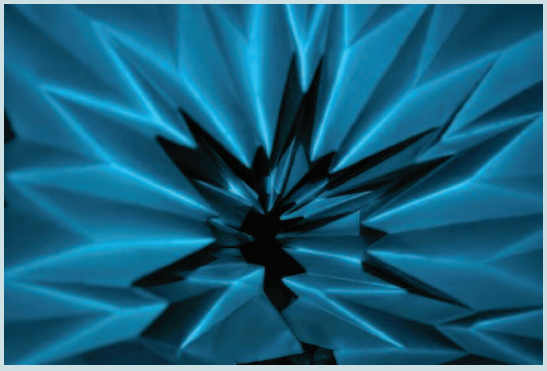
Zinc Oxide Nanostructure Synthesis by Microheaters by Weichih Lin



Nano-probing with a sharp tip; the wonders of scale by Tamaryn Shean



Significance Of Eco-Friendly Concrete by Cise Unluer



Origami Whirlpool by Pooya Sareh

The winning entry for the Department of Engineering's Carl Zeiss video competition shows how engineering students were able to design a new Yacht Club building from scratch, in just one week.

The film, *Valencia Yacht Club Design Video* was made by third-year students at the Department of Engineering as part of project in which they had to design a tension structure for a (fictional) Russian oligarch. In the brief, they were told that money was no object and their client expected something that would "take his breath away". There was only one catch: they were given just seven days to do it.

The team, of Johannes Whittam, David Williams and Michael McCulloch managed to produce the full design for a new building for Valencia Yacht Club's 'high-end clientele'. The structure is designed to resemble a racing yacht sailing through the ocean passing a buoy.

The film, made for the client brief, features an artist's impression of the structure and a 3D model.

Commenting on the first prize award in the video category, the judges said: "Basically the video was just an added extra, a cherry on top of a full week's work in which the students had to come up with an interesting design for a tension structure and do all the complicated, nonlinear structural calculations to show that it would stand up. Even ignoring the video, the design is brilliant on so many levels – architectural and engineering."

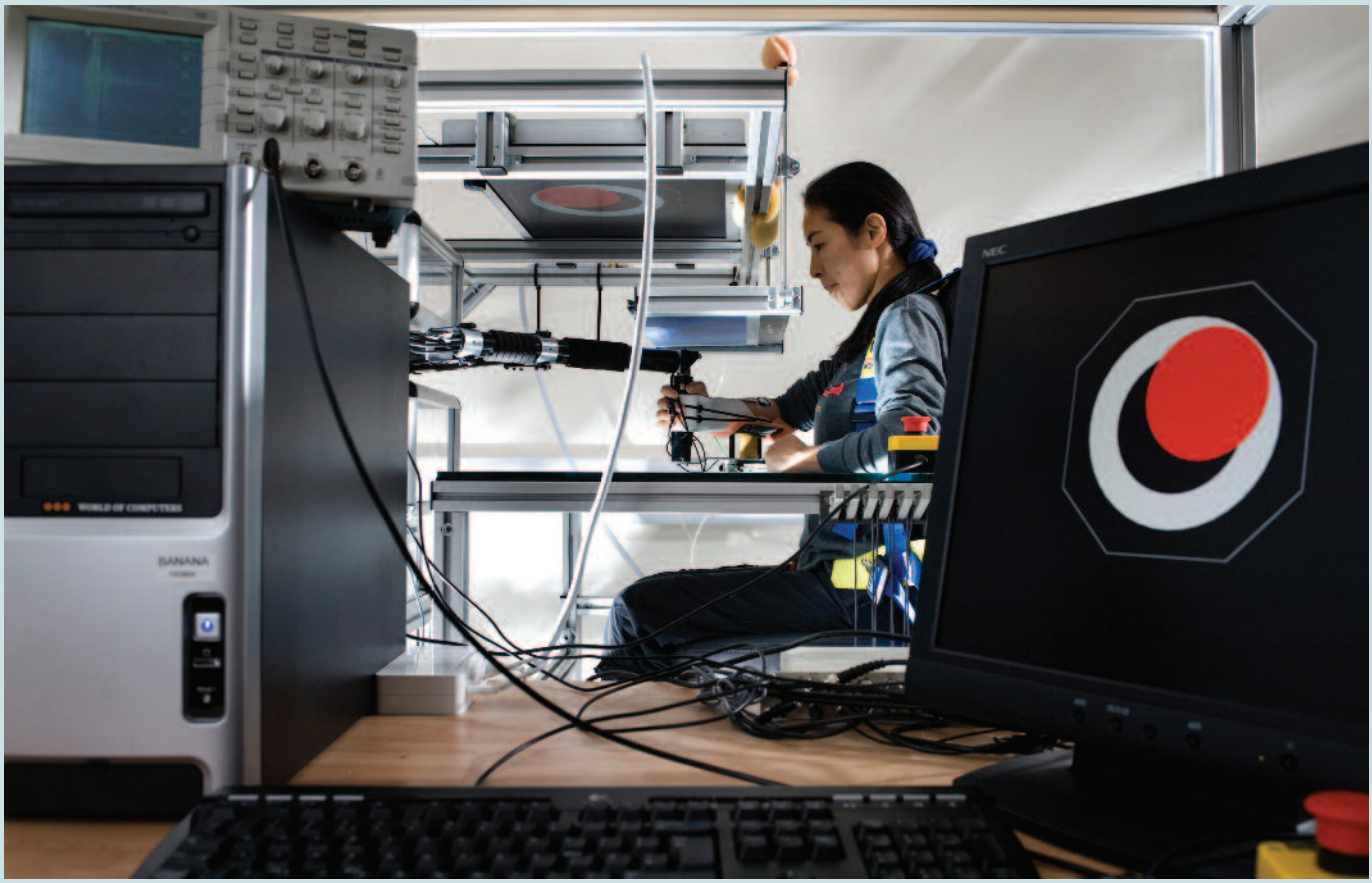
Second prize in the video category was Cambridge University Spaceflight's first-hand view of a parachute being released on the edge of space. The team tested parachutes for the ExoMos lander, a European-led robotic mission to Mars currently under development by NASA and the European Space Agency (see article on p5). The video shows the parachute re-entering the Earth's atmosphere from the edge of space at a robust 450mph.

The third-placed video was *Dancing with the Flame*, shot by a team of four engineers specialising in improving aeroplane engine design to reduce planes' fuel consumption. The footage shows an unstable flame being slowly extinguished inside a combustion chamber.

The winning videos can be watched at the Department of Engineering YouTube channel: www.youtube.com/playlist?list=PL96206140176C9F29&feature=plcp

The man with the golden brain

What's the point of a brain? This fundamental question has led Professor Daniel Wolpert to some remarkable conclusions about how and why the brain controls and predicts movement. In a talk for Technology Entertainment and Design (TED), Wolpert explores the research that resulted in him receiving the international organisation's Golden Brain Award.



A student using a custom-built robotic manipulandum in an experiment to understand how humans control their movements. For more information go to: www.wolpertlab.com

The sea squirt, a type of marine filter feeder, swims around looking for somewhere to settle down for the rest of its life. Once parked on a rock in a suitable spot, it never moves again. So the first thing it does is eat its own brain. While this may seem a little rash to some, for Professor Daniel Wolpert it makes perfect evolutionary sense.

"To me it's obvious that there's no point in the brain processing or storing anything if it can't have benefits for physical movement, because that's the only way we improve our survival," says Wolpert. "I believe that to understand movement is to understand the whole brain. Memory, cognition, sensory processing – they are there for a reason, and that reason is action."

Wolpert is firmly convinced that movement is the underlying factor and final result behind every functional aspect of a brain. "There can be no evolutionary advantage to laying down memories of childhood, or perceiving the colour of a rose, if it doesn't affect the way you're going to move in later life," he says.

A professor in the Department of Engineering, Wolpert examines computational models and uses simple behavioural experiments to describe and predict how the brain solves problems related to action. Through this combination of theoretical and behavioural work, Wolpert has begun to revolutionise the study of human sensorimotor control, the way in which the brain controls physical movement.

He was recently presented with the prestigious Golden Brain Award by the California-based Minerva Foundation. The award is given to those producing original and outstanding research into the nature of the brain, regarded by many as the most complex object in the known universe.

So what occurs in the brain when humans produce movement? Science has long struggled with the mysteries of this question. Wolpert uses the example of the game of chess: "We have computers that can generate algorithms of possible chess moves at tremendous speeds, beating the best human chess players. But ask a machine to compete on a dextrous level, such as moving a chess piece from one square to another, and the most advanced robot will fail every time against the average five-year-old child."

The models employed by Wolpert and his team have yielded startling results, offering a possible glimpse into the patterns integral to our mental matrix. "It turns out that the brain behaves in a very statistical manner, representing information about the world as probabilities and processes, which is possible to predict mathematically," says Wolpert. "We've shown that this is a very powerful framework for understanding the brain."

For action to occur, a command is sent from the brain causing muscles to contract and the body to move. Sensory feedback is then received from vision, skin, muscles and so on, to help gauge success. Sounds simple, but a vast amount of misinformation or 'noise' is generated with even the most basic action, due to the imperfections in our senses and the almost incalculable variables of the physical world around us. "We work in a whole sensory/task soup of noise," says Wolpert. "The brain goes to a lot of effort to reduce the negative consequences of this noise and variability."

The brain's crystal ball

To combat this noise, our brains have developed a sophisticated predictive ability, so that every action is based on an orchestrated balance between current sensory data and, crucially, past experience. Memory is a key factor in allowing the brain to make the optimal 'best guess' for cutting through the noise, producing the most advantageous movement for the task. In this way, our brains are constantly attempting to predict the future.

"An intuitive example of this predictive ability might be returning a serve in tennis.

"I believe that to understand movement is to understand the whole brain."
Professor Daniel Wolpert

You need to decide where the ball is going to bounce to produce the most effective return. The brain uses the sensory evidence, such as vision and sound, and combines it with experience, prior knowledge of where the ball has bounced in the past. This creates an area of 'belief', the brain's best guess of where ball will hit court, and the command for action is generated accordingly."

Movement can take a long time from command to muscles, which can leave us exposed. Like chess, we need to be anticipating several moves ahead, so the brain uses its predictive ability to try and internally replicate the response to an action as or even before it is made, a kind of inbuilt simulator. The brain then subtracts this simulation from our actual experience, so it isn't adding to the noise of misinformation.

"For behavioural causality, we need to be more attuned to the outside world as opposed to inside our own bodies. When our neural simulator makes a prediction, it is only based on internal movement commands. The brain subtracts that prediction from the overall sensation, so that everything left over is hopefully external."

But this can have intriguing effects on our perceptions of the physical world, and the consequences of our actions. "This is why we can't tickle ourselves, as tickling relies on an inability to predict sensation, and your neural simulator has already subtracted the sensation from the signal," says Wolpert.

"But they hit me harder!"

A further example of this sensory subtraction occurred to Wolpert during a backseat bust-up between his daughters, a familiar experience for most parents during long car journeys. The traditional escalation of hostility was ensuing as each child claimed they got hit harder and so retaliated in kind.

Wolpert explains: "You underestimate a force when you generate it, so as one child hits another, they predict the sensory movement consequences and subtract it off, thinking they've hit the other less hard than they have. Whereas the recipient doesn't make the prediction so feels the full blow. So if they retaliate with the same force, it will appear to the first child to have been escalated."

This observation led to a simple but effective experiment being conducted called 'tit for tat', in which two adults sit opposite each other with their fingers on either side of a force transducer. They were asked to replicate the force demonstrated by each other when pushing against the other's finger. Instead of remaining constant, a 70 percent escalation of force is recorded on each go. It seems that we really don't know our own strength.

Deciding to act

The next challenge for Wolpert is to investigate how we make the decision to act, and what happens in the brain if we change our minds after the initial decision. "We think that the fields of both decision-making and action share a lot of common features, and our goal is to try and link them together to create a unifying model of how actions affect decisions and vice versa," says Wolpert.

"As we walk around the world, do our decisions depend on how much effort is required, and to what extent does perceived effort influence the decisions we make? Similarly, to what extent does perceived effort relate to the decision to change our minds? These are the questions we want to address."

To this end, Wolpert is about to begin on a project for the Human Frontiers Science Programme on linking decision to action. "We've developed robotic interfaces in the lab which allow us to control and create experiences that people won't have had before," he says.

"We ask subjects to perform simple tasks using a joystick. Once they are in a rhythm, we generate forces that act proportionally to speed but perturb their arm in unusual ways, such as right angles, and see how they respond. This allows us to build a dataset on novel learning, how people adapt to various forces, and the decisions that they make in the process."

Wolpert's ultimate aim is to apply these models of the brain and how it controls movement to a greater understanding of brain disorders. As he explains: "Five percent of the population suffers from diseases that affect movement. The hope is that we will not only understand what goes wrong in disease, but how to design better mechanisms for rehabilitation."

Wolpert's TED talk can be watched at: http://on.ted.com/AOEB

Cambridge Manufacturing Engineering Design Show 2011

The annual Design Show is a chance for students to show off their ideas to local inventors, industrialists and designers.

Students put together displays to explain the technical and business ideas behind their products, together with design details and prototype models of the products themselves. Below is a summary of last year's impressive design show.

A group of four Manufacturing Engineering students have come up with a new design for an extreme sports device which could save lives.

The Automatic Belay Device (ABD), seen in photograph 7, is the work of four third year students, Chris Bellamy, Emma Crossman, Tom Latimer, Isabel Martinez who are planning to apply for a patent for their design.

The ABD is one of eleven new product ideas developed by students as part of their Manufacturing Engineering course. The designs were on display at the Department's Institute for Manufacturing's annual Design Show, supported by Shearline Engineering.

The ABD device has been designed to allow climbers to use indoor climbing walls safely without the need for a climbing partner. The climber clips into the device and it takes up the slack as they climb the wall. The students are now in conversation with a leading sports equipment manufacturer to obtain a patent and eventually move into production.

Here (right) are a selection of some of the other excellent designs at the show.

The 2012 Design Show will take place on the evening of Wednesday 6th June. If you would like an invitation to attend please email: ifm-events@eng.cam.ac.uk

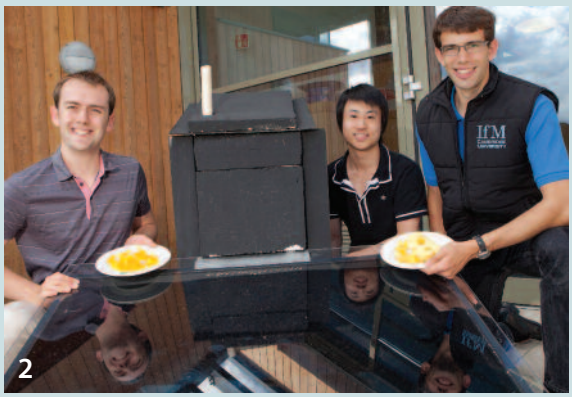
1 Access-a-ramp

An automatic, train-mounted ramp to allow disabled users more independent access to the rail service.
Sam Brown, Jack Danbury, Zoe Eardley, Clare Totman

1

2 Refruitalize

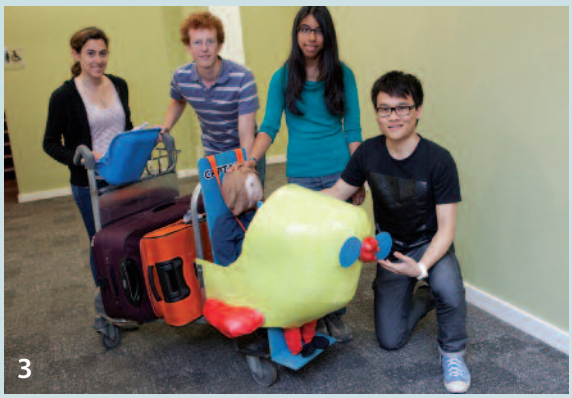
A tropical fruit dryer to provide the basis for dried fruit products in domestic and international markets.
David Clark, Jean Paul Delport, Daniel Ho



2

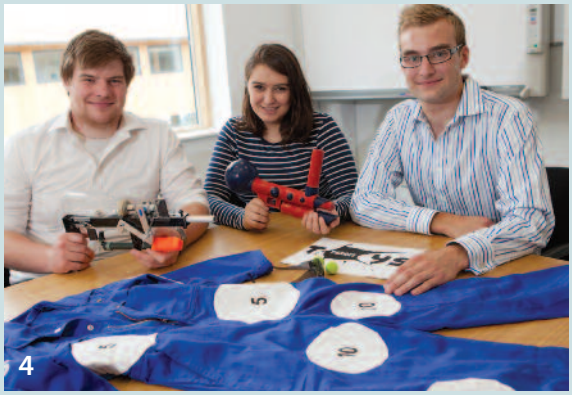
3 Trolliday

A fun airport trolley designed specifically for family travellers with young children.
Doug Byatt, Priya Khetarpal, Sara Montakhab, Jacky Yuen


3

4 Splash Balls

A unique and colourful target game designed for children between the ages of 8 and 12.
Rob High, Chris Jackson, Sadia Sapsard


4

5 GuineaPod

An innovative design that makes keeping guinea pigs at home an easier and more enjoyable experience for adults and children alike.
Kiran McCann, Gemma Raven, Chris Rowe

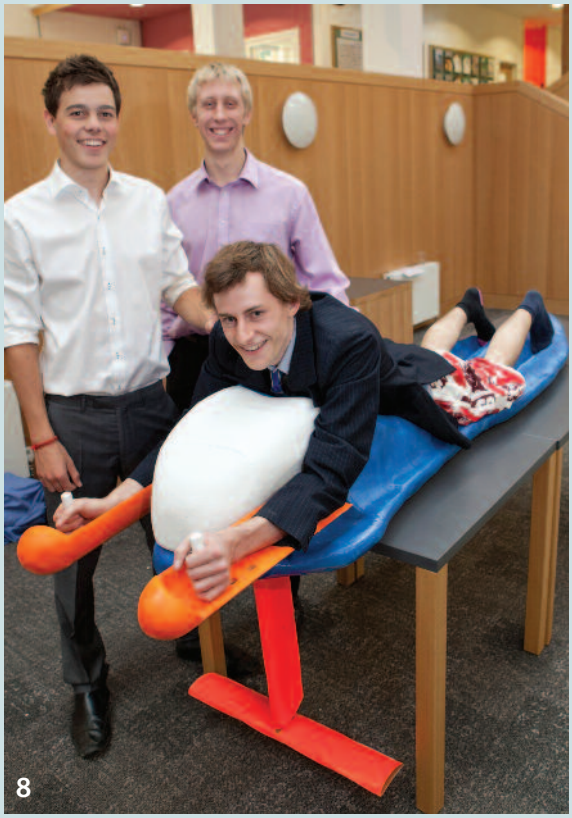

5


6


9


7


10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11

6 Epione

MLD device for self-treatment of Lymphoedema.
Alan Cruickshank, Mart Nitibhon, Emily Wakeford

7 The Automatic Belay Device

An automatic device to lower climbers safely to the ground in indoor climbing centres.
Chris Bellamy, Emma Crossman, Tom Latimer, Isabel Martinez

8 Foilfly

A face-down, flying-above-the-water sensation for the leisure rental market.
Ewen Christie, Laurence Gartside, Ben Kenneally

9 Collapsi-Sled

A novel, space-saving sledge, designed for expedition use.
Jeni Hine, Markos Markides, George Savell

10 MeltWater

An energy-free, non-freezing livestock watering solution.
Emma Cory, Angus Sinclair, Chris Wright

11 Rokuyurt

An innovative, mid-to-long-term housing solution aimed at disaster victims and refugees.
Simon Bourne, Fiona McHardy, Angharad West

For more information
www.ifm.eng.cam.ac.uk/met/design/default.html

Facing up to Fukushima

In the wake of the disaster at the Fukushima reactor, Japan and other nations are re-evaluating their attitude to nuclear energy.

Cambridge academic Tony Roulstone believes it is vital for governments and industry to develop nuclear strategy proactively and openly in light of this incident.

With media coverage of the earthquake aftermath focusing on the Fukushima power plant and possible worst-case scenarios, the question of safety in nuclear energy has returned to the forefront of many people's minds around the world. Japanese Prime Minister Naoto Kan recently announced that his government will be 'starting from scratch' with its energy plans and the country's reliance on nuclear power following the crisis.

Tony Roulstone, course director of the nuclear energy graduate programme at Cambridge, argues that the Fukushima reactor may have long held the potential for an incident of this nature, being an old power plant with a flawed design, which doesn't reflect contemporary nuclear capability.

"The safety standards that these old reactors were built to are nothing like today's standards. Fukushima is the second oldest Boiling Water Reactor (BWR) in the world, completed in 1971. Some of these early models have a weak design. At the very time you need the containment facility to protect you, when the core is overheating, you have to vent pressure and consequently possible radiation to prevent explosion.

"The reactor and the radiation containment should last at least a week after an incident without external help; this is the way modern reactors are designed. Nuclear safety is very simple: Don't damage the core, make the containment effective. But what do you do about these old reactors? We can use our ingenuity to try and fix them, or shut them down, but either way we need to address the problem."

The earthquake didn't damage the reactors themselves, but did take out mains electricity. The ensuing tsunami knocked out the diesel generators and other back-up systems that were used to pump water around the core, keeping it cool. Once that power failed, the core overheated and was critically damaged a mere 26 hours after the tidal wave hit.

Roulstone calls this 'common cause', where the initiating event triggers a domino effect that inevitably leads to core damage. In this case: tsunami hits, grid goes down, batteries fail, cooling pump stops, core damage results. "You can't have a reactor which destroys itself within 26 hours when all you need to do is pump water in – this is unacceptable. More batteries, more diverse pumping systems, whatever the cost. If all you have to do is get water into the reactor and heat out, then that's what you've got to do!"

Nuclear engineering has come a long way since the construction of the Fukushima plant. Modern reactor design has focused on the threat from 'external hazards' during the last 20 years: earthquake, terrorism, plane crash, flooding, and so on. Safety systems, such as the pump and generators that went down at Fukushima, are now built to the same robust standards as the reactors, preventing the potential for a 'common cause' cascade of failure.

When the Fukushima plant was built forty years ago, core damage frequency was predicted as once in every 1,000 reactor years. Following the meltdown at Three Mile Island in the US in 1979, reactors were modified to reduce the likelihood of core damage to at least one in 10,000 years.

According to Roulstone, the trend has continued to increase dramatically: "Plants from the 80s and 90s such as Sizewell in the UK have an expected core damage of once every 100,000 years, and the new generation of nuclear plants are being built to once every 1 million years, as good as we can do." In fact, Japan itself is home to the first (3rd generation) advanced reactors, which have been operating since 1996.

But this still leaves the question of what to do with old reactors such as Fukushima, and how to address the worldwide perception of nuclear power following coverage of such disasters in a media-saturated age, which tap into the public fear of nuclear radiation still prevalent from the Cold War and tragedies like Chernobyl.

For Japan, a heavily industrialised island nation with very little natural energy resources, there are no easy answers. "The Japanese committed to nuclear power because they had no other option," says Roulstone. "Post-Fukushima, all they can do in the short term is import gas and fossil fuels. The only way they'll reassure the public about nuclear energy is by saying: 'we don't care about past energy policy, we need to look at everything on its merits right now as they stand'."

This openness in communication to the public from governments and the nuclear industry is something that Roulstone sees as crucial, on a local and global level. "In nuclear, what happens in one country affects everyone else. The Japanese haven't yet been open enough with the global community; they need to get more international people involved. The industry needs to be seen to be learning from this the only way we can progress effectively is by being open and responsive."

For Roulstone, the question of how to deal with ageing reactors such as Fukushima is a thorny one, but this is not the time to shy away from these issues. "As an industry, we need to learn from this and make things substantially better, not just a little bit better. We learned a hell of a lot about operating and designing reactors from Three Mile Island… the game is to learn from accidents – making these so remote that the public can trust nuclear to generate the energy we need"

"You don't live without risk; the question is what you do about it in these situations. You either give up or you tackle things and make progress."

The Cambridge Nuclear Energy Centre website: www.cnec.group.cam.ac.uk

Sustainable innovations in the built environment

The Eco-House Initiative links students, academics, industry, NGO's, governments and local partners in the development of sustainable housing systems and urban planning for the developing world.

An Un Techo para mi Pais house under construction

The Eco-House Initiative is a multidisciplinary programme that aims to facilitate truly sustainable growth in the context of poverty and climate change in the developing world by linking academics, industrial partners, Non-Governmental Organistions (NGOs) and governments. The Initiative researches, designs and builds affordable sustainable housing systems and communities for the urban poor with local organisations, as well as raising awareness of the issues of sustainability and poverty in the region.

"The Eco-House Initiative brings fresh innovations developed with local partners and industry. It aims to deliver applicable eco-friendly solutions to provide housing access for the poor, as well as plan the sustainable growth of cities with local authorities in order to reduce carbon emissions."
Jose Vallejo

The Cambridge University Eco-House Research Cluster is part of the Initiative and provides academic support. The cluster is a collaboration between leading academics in the Departments of Engineering, Architecture and Land Economy as well as the Cambridge Engineering Centre for Sustainable Development and the Cambridge Centre for Housing and Planning Research. The cluster focuses on sustainable housing, planning and urban development research in low-income countries.

The Eco-House Initiative is currently working in partnership with local organisations and governments in Latin America on transitional and permanent housing systems and urban planning. The Initiative is also carrying out research into eco-friendly communities and permanent housing systems that are appropriate to the developing world. Strategic partnerships have been agreed with South American Municipalities, providing the Initiative with unparalleled access to information across all aspects of the urban planning system and setting a strong basis for future collaborative research.

The transitional housing work is being developed and implemented in partnership with Un Techo para mi Pais ('A Roof for my Country') an organisation that operates in 19 out of 20 countries across Latin America. They have built more than 80,000 transitional houses with the help of some 420,000 volunteers, and are growing fast – almost 32,500 houses were built in 2010 alone. The Eco-House Initiative is currently designing innovations to improve the durability and quality of service provided by Un Techo para mi Pais's transitional house, with a prototype due to be completed and erected in Cambridge in March 2012. Further prototypes will be built in Ecuador and Brazil this summer as more volunteers are sent on in-country field-research placements. The plans for the Initiative are to shift the main focus onto permanent housing design systems, with a full-scale permanent housing pilot project in Ecuador and Brazil by summer 2014.

The world faces unprecedented challenges from continued population and economic growth, rapid urbanisation and climate change. There are currently seven billion people in the world. By 2050 this will have grown to nine billion, with 80% of them in the developing world. At present, 80% of global carbon dioxide emissions are generated by one third of the global population that lives in developed countries. Considering that the built environment is responsible for 40% of total carbon dioxide emissions, what will happen if the developing world grows unsustainably?

There are currently eight doctoral and masters-level research projects under the Initiative, as well as almost 100 students who are actively involved in the research, design and testing. Over the last year, 12 volunteers spent a total of 60 weeks gathering field data in Ecuador and Brazil, to serve as a baseline for evaluating proposed design innovations. All of the students are from Cambridge University.

With the support of a growing network of academics, industry partners, strategic partners in the local municipalities, its partners NGO, Un Techo para mi Pais, Cambridge University Eco-House Research Cluster and of course their invaluable student volunteer base, the Eco-House Initiative is well on its way to delivering truly sustainable solutions to the housing challenge in the developing world.

This fusion of innovation and real world application has the potential for a huge impact in helping to eliminate poverty while reducing carbon emissions and resource consumption.

There are boundless opportunities for industrial partners to participate, for example, on the design or as advisors on innovative practice. The Eco House Initiative's fusion of fresh design and real world application has the potential to make a huge impact in helping to eliminate poverty while reducing carbon emissions and resource consumption.

To find out more about how you or your organisation can get involved, please contact the Eco House Initiative team: Email: cambridge.ecohouse.initiative@gmail.com Tel: the director, Jose Vallejo, on 07769 971 604.

To follow the Eco-House Initiative's progress, please visit www.ecohouseinitiative.com

Please take a look at Eco House Initiative's video to see how they and the biggest NGO in Latin America are working together. By viewing, you are supporting The Eco House Initiative in the Royal Bank of Scotland Enterprising Student Society Accreditation competition for an exciting amount of funding. www.youtube.com/watch?v=FLQDUcSU3vg

Metail: translating cutting edge research into commercial

A start-up company established by a team including several Department of Engineering alumni is on track to revolutionise the world of fashion.

Metail (www.metail.co.uk) is a London- and Cambridge-based company that has developed cutting-edge technology intended to help shoppers buy clothes online. By providing a few measurements via a web-based user interface, users can create accurate 3D models of their own bodies. These are used to make garment size recommendations and to visualise how clothes will hang to fit the body. Metail's web user interface is designed to be integrated directly within existing e-commerce websites and provides significant benefits to retailers including increasing customers' confidence to buy and reducing operating costs. By applying state-of-the-art technology in a way that is focussed on the needs of both consumers and retailers, Metail plans to eliminate the barriers to online clothes shopping.

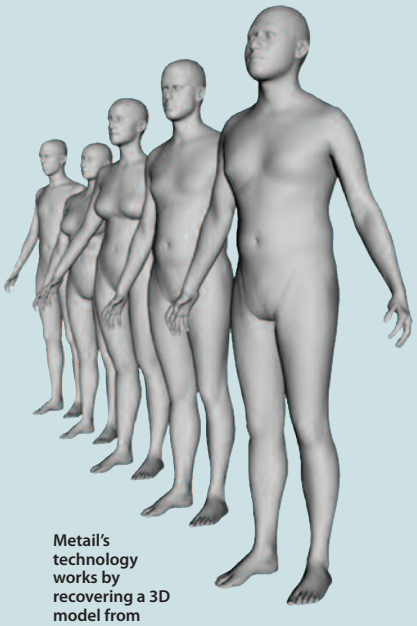
Metail was founded in 2008 by Chief Executive Officer Tom Adeyoola (Economics, 1994) and Chief Scientific Officer Dr Duncan Robertson (Engineering, 1994 and 1999), both alumni of the University of Cambridge. Duncan is a former PhD student of Professor Roberto Cipolla, head of the Computer Vision and Robotics group within the Machine Intelligence Laboratory at the Department. Roberto also played a significant role in the creation of Metail. Not only were the results of cutting edge research carried out within his group influential in convincing Tom that Metail's key technological problems could be solved, Roberto was also responsible for introducing Tom to Duncan, and providing technical advice. Metail has also collaborated closely with another of Roberto's PhD students, Yu Chen, providing financial support for his PhD as well as a commercial focus for his research efforts. Yu Chen now works full time at Metail, and the company employs a total of seven Department of Engineering alumni, including Chief Technical Officer Jim Downing, Head of Operations Ed Clay, and Board Chairman Charles Tavner.

To date, Metail has been successful in obtaining funding, launching a beta version of its product via Facebook, and expanding its team. The company was established using investment capital provided by friends and family investors. Since then the business has raised more than £2M in equity funding from private individuals. Having taken on its first employee in April 2010, the company now employs 18 full time staff who are divided between its technology, operations, and marketing teams. At present Metail is initiating large scale commercial trials with Tesco, one of the UK's largest retail businesses and a big name department store.

Metail isn't the first start-up company to try to sell technology related to garment visualisation and size recommendation. Several others have tried – and failed – in the past. However, Metail's management team believe that they have the right product at the right time. Today, fashion e-commerce is one of the fastest growing Internet sectors with a UK growth rate of around 20% per annum. However, persuading new and existing customers to shop for clothing online remains a significant challenge for retailers. The key problem is to give customers sufficient confidence to buy by addressing their concerns about suitability and fit. Metail's technology addresses both of these concerns, and also reduces the cost to retailers of catalogue photography and handling customer returns.

A large part of the reason why Metail is

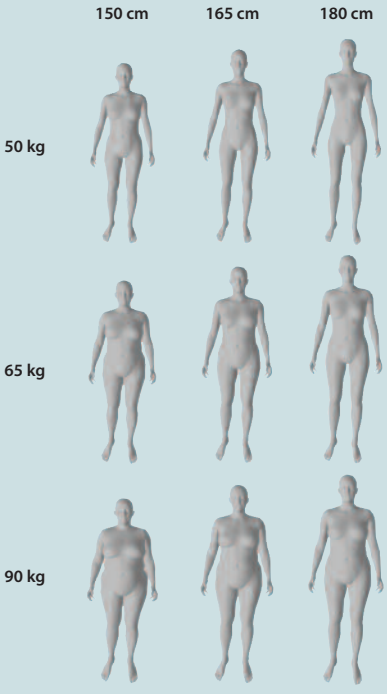
By providing a few measurements, for example by uploading a photograph of themselves wearing tight fitting clothes, users can create accurate 3D models of their own body shapes. By uploading a single face photograph, users can also visualise their own heads – and even try out different hairstyles. These models can be used to visualise different outfits and to make accurate size recommendation.



Metail's technology works by recovering a 3D model from measurements provided by the user, for example some physical measurements like weight or height, a 2D silhouette extracted from a photograph, or a depth image obtained by a Microsoft Kinect sensor.

In general the task of recovering a 3D model from a limited set of measurements is hard – many possible 3D body shapes could give rise to nearly the same set of measurements. However, by comparing the input measurements with a database of nearly 5000 male and female body shapes, Metail's software can make confident body shape predictions given a relatively small number of measurements (e.g. weight and height).

More measurements make it possible to capture the nuances ('column' and 'pear' body shapes).



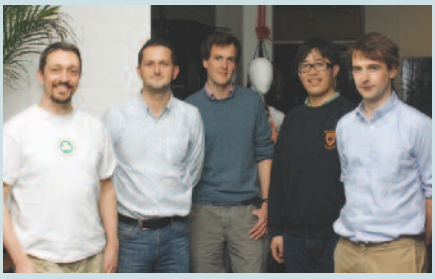
succeeding where others have failed is the ability to commercialise research quickly. Thanks to recent advances in the field of computer vision, it is finally possible to create accurate 3D models of users' body shapes and for retailers to create photo-realistic garment models in a way that fits in with their existing catalogue photography processes. However, transforming research ideas into a commercial product has not been without substantial challenges. Duncan describes how Metail has worked hard to overcome some of these: "Much of Metail's core body modelling and outfit visualisation technology is based on recent computer vision research, including some of the excellent work conducted by Professor Cipolla's group within the Department of Engineering. Whilst much of this work has been published, the most valuable IP isn't really vested in publications or patents, but in people's heads. For Metail, the ability to work directly with researchers has been essential to effective technology transfer. In large part, our success in developing cutting-edge technology can be attributed not to formal processes for technology transfer but to personal relationships with people inside the research community.

"The differing priorities of researchers and business managers can sometimes present significant barriers to effective collaboration. Researchers solve problems because the solution is novel, not necessarily because it is commercially relevant. In consequence, problems often become less interesting to researchers right at the point when they become more relevant to business managers. In this regard, I think Metail did well to put both researchers and business people in the boardroom from day one. This is a significant benefit of the start-up model. Shared equity cements and aligns people's interests in a way that is hard to achieve via contractual mechanisms alone. Today Metail continues to expand its research team in-house, recruiting not only first rate researchers but also experts in technology transfer.

"Integrating research output into commercial software systems presents some unique engineering challenges. Research software is often inherently complex and the iterative nature of the research process means that prototype implementations are often inefficient, poorly written, and relatively untested. Building production software around such prototypes is inevitably difficult. Planning development work effectively is a particular challenge. The credibility of start-up companies with their investors and their customers depends critically on hitting deadlines, but research-oriented projects inevitably involve a disproportionate amount of uncertainty and risk. Metail did the right thing by practising early integration of our research technology with our prototype web platform. This turned out to be extremely important from the perspective of our relationships with our customers. First, our early demos were a useful means of convincing retailers to believe in our vision for the technology, even before that vision was fully realised. Secondly, because we were able to demonstrate working prototypes relatively early on in the development cycle, we were able to harvest the valuable customer feedback that prevented us from making completely the wrong product.

"Sometimes there remains something of a cultural divide between research, development, and product and marketing teams. It is very easy for business managers to underestimate the massive amount of commercial value that research provides. But conversely, it is very easy for researchers to underestimate the massive amount of effort required to develop research software into production-ready, commercial systems and to sell those systems. Within Metail constant communication has been critical to enabling all teams to work together effectively.

"Finally, despite all our best efforts, sometimes things didn't go quite as we hoped. It is in the nature of research that it doesn't always deliver exactly what is wanted, when it is wanted. The old adage 'plan for success but be prepared for failure' has been relevant here. But having a clear vision of where we wanted to go and being able to communicate that vision to investors and customers alike was essential. Even when things didn't work out as well as we had hoped, we worked hard to leave no one in any doubt that we would continue to build on the starting point we had established and deliver on our vision."

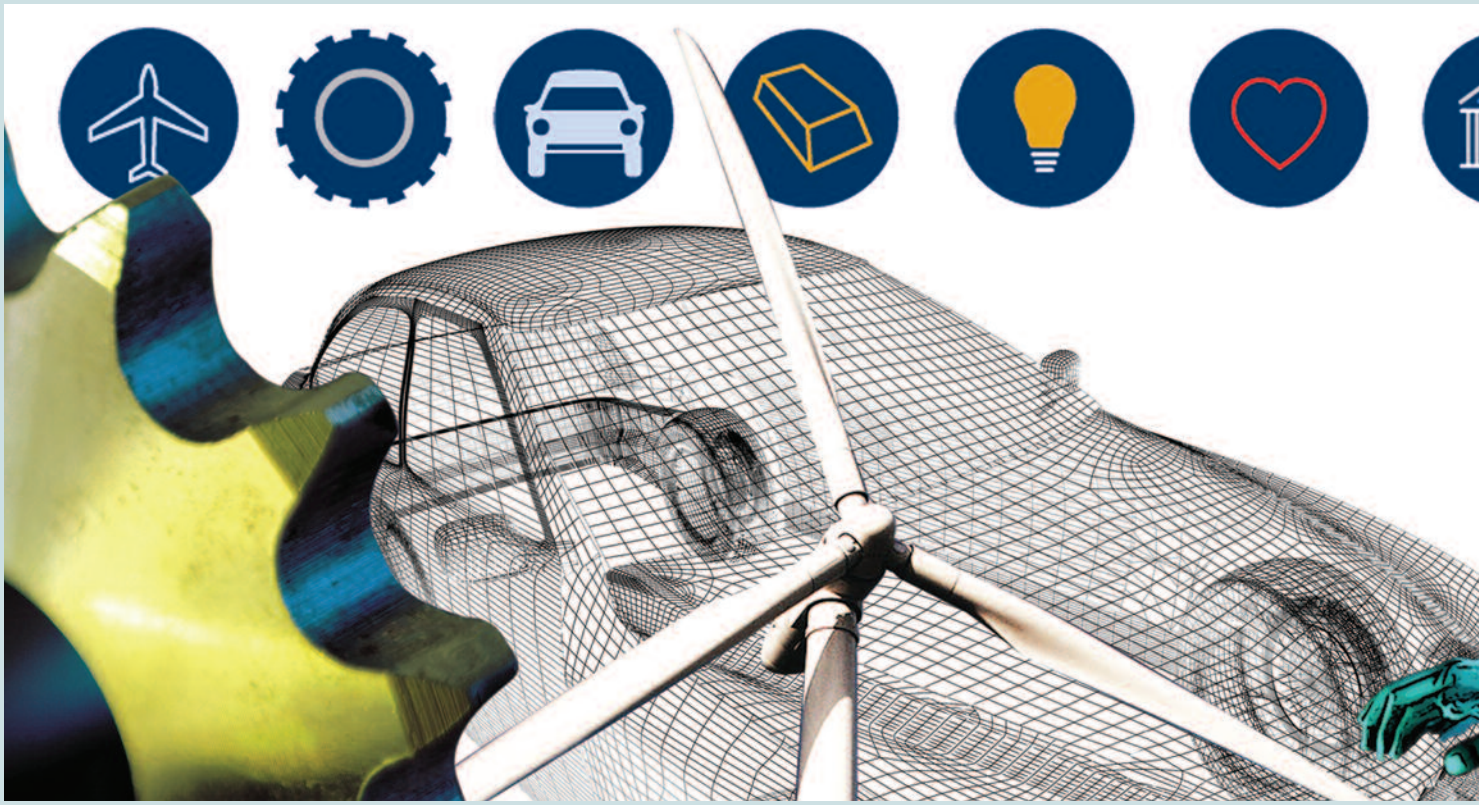


Metail's Department of Engineering alumni: from left to right, Jim Downing (1995), Duncan Robertson (1994, 1999), Edward Clay (2002), Yu Chen (2008), Charles Tavner (1994)

For further information about Metail please visit www.metail.co.uk

It's a material world

A spin-out from Cambridge's Engineering Department and a leading supplier of materials information technology software to industry, Granta Design has achieved an average growth of 30 per cent over the past ten years.



A specialist company that span out of the University of Cambridge Department of Engineering in the 1990s is now the world's largest company in the niche area of materials information technology.

With a client base across the world, and as a supplier of software to some of the top names in industry, Granta Design has achieved an average growth of 30 per cent over the past ten years. Based in Cambridge, it has retained its strong links with the University and over the summer it employed its largest ever group of paid interns from Cambridge and elsewhere.

Granta Design is unusual in that it works both with the education sector, the area within which it originated, and with industry, which has accounted for much of its recent expansion. In the education sector it is the leading provider of university-level teaching resources on materials science and related topics. Its activities in the industrial sector fall into three main areas: materials data management; materials decision support; and eco design (materials and the environment).

"We work at the interface between materials science and information technology," said chief operating officer Patrick Coulter. "Our software helps designers and engineers to choose materials and to control and use the complex materials data that they get from testing, research, suppliers, or the wide range of available reference sources. We are constantly updating our products.

"Last year we launched interfaces to the 3D computer-aided design (CAD) packages that are the routine working environment for many engineers. These interfaces provide Granta tools within very widely-used design software, such as Autodesk® or Pro/ENGINEER®, allowing users to find materials data and use it in their product analysis."

A recent area of expansion has been eco-design, with an increasing focus on materials and their environmental impact driven partly by regulations and partly by market demand for more environmentally-friendly products. Granta Design provides tools that help engineers working early in the design phase of a product to make a rapid assessment of its environmental impact. The company also helps companies to avoid use of restricted substances that may be harmful to health or the environment.

"We've applied scientific rigour to an area which can sometimes lack substance," said Coulter. "For example, we help people to quantify the likely carbon footprint over a product's lifetime for a given design. A choice that lowers carbon emissions in one area, such as during use of the product, may increase them elsewhere, perhaps in producing the raw materials. So it's important to base design decisions on a good methodology and hard numbers rather than the latest green hype."

The company's history goes back to 1994 when its founders, Professor Mike Ashby and Professor David Cebon, were working in the Engineering Department at Cambridge. Their skills were complementary with Ashby's expertise lying primarily in materials science and Cebon's specialism chiefly in information technology and mechanical engineering. Passionate about educating young engineers about materials, Ashby was writing text books that remain standard reading for undergraduates. The innovative bubble charts he devised in order to illustrate the relationship between function and properties of materials are known as the "Ashby charts".

Realising that their students in the Engineering Department in Cambridge would benefit from modern tools to help them get a better grasp of materials, Ashby and Cebon began to develop software that helped students explore the world of materials properties and understand why particular materials might be selected for an engineering application. Soon word spread and other institutions began asking to purchase the software for use on their own courses.

Ashby and Cebon set up Granta Design with a small grant from the Leverhulme Trust,

GRANTA DESIGN

"Our software helps designers and engineers to choose materials and to control and use the complex materials data that they get from testing, research, suppliers, or the wide range of available reference sources."
Patrick Coulter

and an agreement about intellectual property with the the University, which still has a share in the company. The firm's first premises were a "kind of farm barn" in Trumpington, on the outskirts of Cambridge. "Those early days were great fun as there was a terrific sense of adventure in what we were doing," remembers Ashby.

In the early years Granta Design concentrated primarily on the education market, with teaching resources and software going to universities. Today this sector still accounts for a third of the company's revenue, with Granta's products used at over 800 universities and colleges worldwide. The educational strand of its activities is an important part of its overall ethos.

From the late 1990s onwards, Granta Design began to work with industry, providing off-the-peg software that supported materials selection and helped materials engineers to manage their materials data. Choosing the right material is a prime consideration for anyone designing a new product and can be a difficult task, with the need to balance various engineering, economic, and environmental factors, not to mention tracking new and developing materials. Many industries, particularly highly-regulated sectors such as aerospace and medical devices, also need to validate rigorously the properties of the materials that they use, requiring a significant effort in testing and analysis.

The company's client base includes some of the best known names in aerospace such as NASA, Rolls-Royce, Boeing, Honeywell, Eurocopter, and EADS Astrium. Use of its technologies is spread across a wide range of other sectors, with clients including Emerson Electric, GE, TRW Automotive, and Renault F1. Coulter joined the company part-time in 1997 and full-time in 1999. His background in chemistry includes a Cambridge PhD and in the early 1990s he founded another Cambridge spin-off, molecular modelling company, Cambridge Molecular Design. CMD was bought out by a US company and is still present on the Cambridge Science Park as part of Accelrys Inc. "I learnt a lot about how to grow a high-tech software company in a sustainable way and I was able to apply this at Granta Design," he says.

Over the years Granta Design's workforce has increased from an initial six to a present roll call of around 80. Around 60 per cent of its employees were born outside the UK and the company has a strongly international flavour. Quite a number of its people are Cambridge graduates – and some began their links with the company as paid interns on placements or over the long vacations. Julia Attwood is a Cambridge graduate who has worked at Granta Design over the past few summers. Now about to embark on a PhD, also at Cambridge, she described working for Granta Design as an "incredible experience" in terms of the opportunities for learning that it offered.

"I've been fascinated by materials ever since I was at school and really enjoyed chemistry, and in my undergraduate degree materials science was my favourite course," she said. "I'm taking a PhD in advanced composite material design in the materials group of the Engineering Department. In the longer term I envisage staying in research, whether in academia or industry."

Last summer Granta Design had 12 paid interns from British and overseas universities working as part of its teams. "Having these bright and highly motivated people working with us has all-round benefits," says Coulter. "For them it's a taste of the real world, and a chance to get some professional experience under their belts and for us it's a great opportunity to reinforce our links with academia and spread the word about our products."

Granta Design website:
www.grantadesign.com

Alumni feature: Six – A fulfilment system to achieve world-leading accuracy

Two engineering graduates James Strachan and James Hyde tell the story of how they came to start up an order fulfilment service built on the same technologies as the web-shops it serves and with which it integrates.

"Back in 2009 James and I were hitting a bit of a low as it was clear our previous enterprise had failed to grow any legs. After a fairly embarrassing round on the temping circuit – you'd be amazed how hard it is to get a temp job with a Master's degree – we fell in, quite by chance, with a local health food importer who had big ambitions.

"As a mini-consultancy project, we started working a few hours a week for them refining and streamlining their processes and improving their e-commerce capabilities. Over the weeks and months, we got to know their business inside out and continued working with them as their company grew.

"It was in the course of our work with them that we first came across the order fulfilment industry – warehouses which specialise in the picking, packing and posting of products on behalf of sellers.

"Most consumers are unaware these even exist, and while many traditional sellers persist in running their own warehouse, the rise of online selling has created a considerable and growing demand for outsourcing this part of the supply chain. During our search for a fulfilment house to recommend, we became steadily disappointed by the services on offer.

"Dim industrial units littered with stacks of boxes and scrawled paper were all too common, and even those in modern facilities still had antiquated systems reminiscent of the days when MS Access ruled the roost. These were not the high-tech, RFID'd and barcode-festooned wonderlands that the trade shows would have you believe. They were someone's spare space; a sideline for freight companies and mailing houses, who'd been asked if they could help out with e-commerce orders by existing clients.

"Entrusting all one's stock to another company is a very big decision to make – the reason why so many still muddle through in-house. The amount of visibility, control and reassurance provided by those facilities we visited was disheartening.

"Among claims of '97% accuracy' and offers of weekly stock reports we began to see that few of these companies were addressing anything more than the basic needs of the new breed of online sellers. Even those offering online services were doing so in a manner which seemed conspicuously bolt-on.

"We saw a gap. In the summer of 2009, we laid the foundations of an idea which would take eight months to materialise: an order fulfilment service built on the same technologies as the web-shops with which it integrates. A first class citizen of the cloud, benefiting from the huge advances in performance and practices achieved in the last decade online, and exposed using the same rendering engine that enables giants like Google and Amazon to share their data with the world.

Alumni James Strachan and James Hyde at their fulfilment house 'Six'

"Jump to the present, and it's been nearly two years since Six (a name mostly chosen for its brevity) fulfilment house opened its doors. Six offers a range of fulfilment services, ensuring the safe storage, picking, packing and despatch of its clients' products to consumer and trade customers. Orders are retrieved automatically via secure cloud servers from online e-commerce stores, marketplaces such as eBay and Amazon, as well as more traditional methods such as postal and telephone orders. Once received, orders are allocated to pickers automatically, ensuring the most efficient allocation. The system has enabled outsourced fulfilment to offer clearer and more immediate stock and order information than sellers could achieve for themselves in-house.

"We've also concentrated heavily on the user interface, choosing to display graphical data that tells clients answers or guides them towards more profitable decisions, rather than out-putting large tables of raw data. Recently we created a new inventory report focusing on the forecast status of inventory rather than absolute quantities. It shows inventory by categories such as low stocked, short dated, overstocked, negative ROI, order soon etc. We already know the product margin, historical sales trends, best before end date and current stock, so it's just a case of crunching the numbers. Most companies might calculate these figures once a year – we can do it every time our clients refresh the page.

"While not without its challenges, the time since has gone remarkably smoothly. Six hit break-even in August 2010 and quadrupled in size last financial year, but more impressive is that most of Six's clients are now recording significantly higher margins."

For more information visit: www.ecommercefulfilment.co.uk