OCTOBER 2014 | Issue 2

Institute for Manufacturing REVIEW

Smart approaches to procurement & resilience
Making the shift to services
Managing risk in industrial investment
New business models for sustainability
Innovation through design

IfM MANAGEMENT TECHNOLOGY POLICY

UNIVERSITY OF CAMBRIDGE

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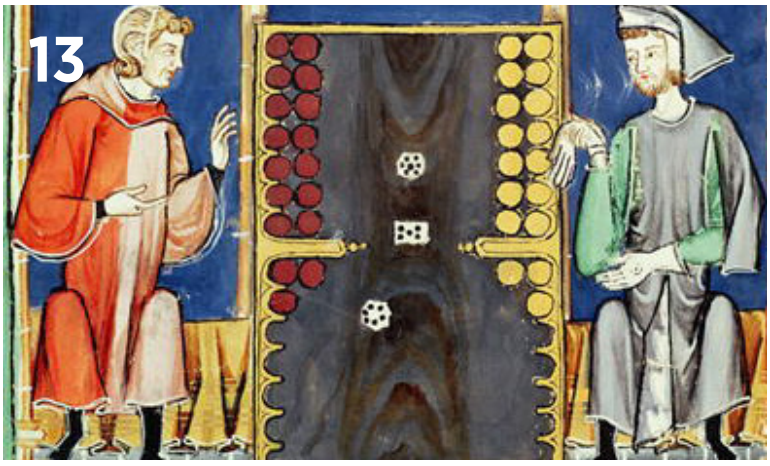
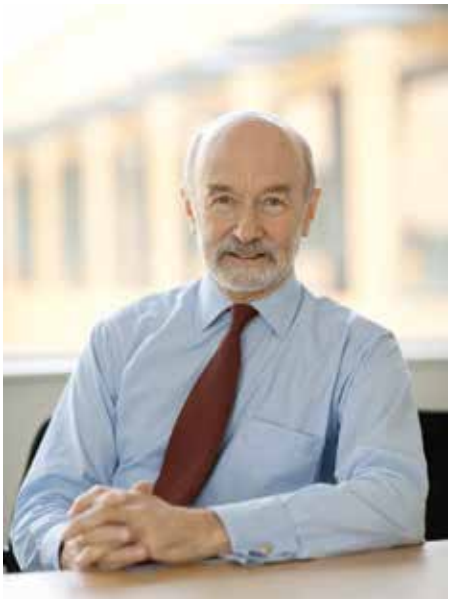


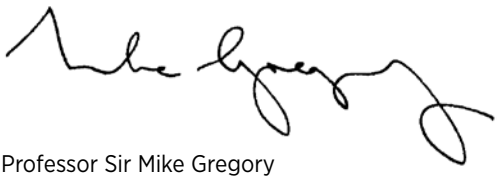
Cover image: Electrospun gelatin fibre mats for tissue-engineered cornea made by Khaow Tonsomboon in the laboratory of Michelle Oyen, Bioengineering, University of Cambridge. Imaging carried out using Helium Ion Microscopy by Ronan Daly (Institute for Manufacturing) and Alan Bell (Advanced Microscopy Lab, Trinity College Dublin).

Welcome

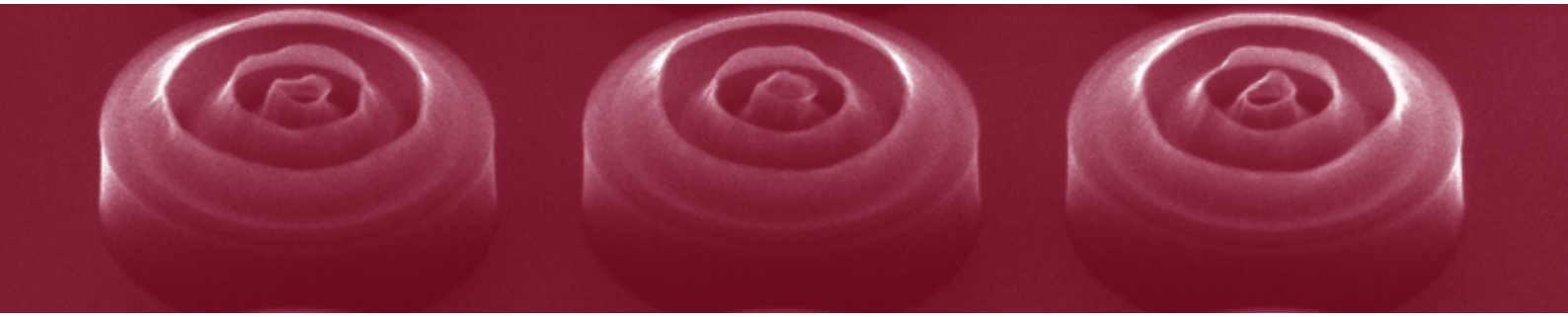
I am pleased to report that the first edition of our new *Review* was warmly received by partners and friends. The editorial team has done a great job bringing together a mix of news, updates and more comprehensive reports on key IfM activities. We hope that everyone will find something of interest. For old friends, something they didn't know about IfM. For new friends, a glimpse of the range of activities across today's IfM – linking engineering, management and policy through education, research and close engagement with practice.



The renewed enthusiasm for manufacturing continues to spread around the world and in recent months IfM teams have been involved with industries, governments and academic institutions in India, Japan, Korea, Brazil and the US. At home we have been asked to lead the next round of the UK High Value Manufacturing Landscape Study involving Innovate UK (formerly Technology Strategy Board), the Department for Business, Innovation & Skills, the Engineering and Physical Sciences Research Council and the Biotechnology and Biosciences Research Council. We believe the new Landscape can help to build on the increasingly coherent national approaches to industrial strategy, industrial futures, manufacturing research and translation – all areas where IfM continues to play a very active role.



Professor Sir Mike Gregory
Head, Institute for Manufacturing



Credit: Michaël De Volder: *Nanotube structures fabricated by capillary self-assembly and regrowth*

IfM Review is published twice a year. Sign up to receive a copy by email and to hear about other IfM news at:
www.ifm.eng.cam.ac.uk/ifm-review

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IfM news

New lecturer

Dr Frank Tietze has been appointed University Lecturer in Technology and Innovation Management. Frank is joining us from the Institute for Innovation Research at Kiel University. His research focuses on innovation at the intersection of management sciences and business (micro) economics and he has previously been a visitor to the IfM's **Centre for Technology Management**.

More ultra precision MRes students

The **Centre for Industrial Photonics** runs the EPSRC Centre for Doctoral Training in Ultra Precision Engineering jointly with Cranfield University. This October it will be welcoming 15 new students onto its MRes programme, its largest intake to date. The MRes aims to produce engineering leaders with a high level of knowledge and skills in ultra precision combined with strong business and management capabilities. The Centre has recently been awarded an extension of its training grant and will now run for a further seven years.
For more information, go to: www.CDT-UP.eng.cam.ac.uk

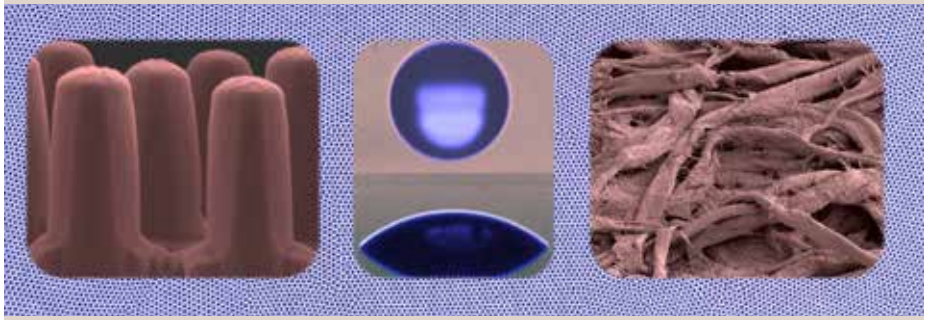
Researchers and industrialists share insights on global value networks

The **Centre for International Manufacturing**'s recent report *Capturing value from global value networks* (published in April) provided the focus of this year's Cambridge International Manufacturing Symposium, looking at its implications for manufacturing, supply chains and industrial policy. More than 100 delegates from industry and academia attended the two-day conference in September and heard speakers from multinational companies including Grundfos, Caterpillar, Unilever and Lockheed Martin. Read more at: www.ifm.eng.cam.ac.uk/research/global-networks

Fluids in advanced manufacturing: new research group

Dr Ronan Daly, University Lecturer in the Science and Technology of Manufacturing, has set up a new research group at the IfM. Its focus is the science of polymeric, biological and nanomaterials when they are exposed to advanced fluid-based manufacturing techniques as well as the challenges associated with fabrication, metrology, characterisation and manufacturability.

As new technologies emerge from scientific research, such as biosensors based on nanomaterials and self-assembled functional polymeric materials for regenerative medicine, the UK needs to have the manufacturing technologies in place to capture value from these developments. This relies on cross-disciplinary collaboration between laboratory-based research groups, manufacturing management research as well as industrial partners. The group's aim is to bring together the expertise in these areas to look at the whole manufacturing system for emerging technologies, identify the risk factors involved and provide a route to successful translation to a scaled-up process through advanced manufacturing engineering solutions underpinned with a deep scientific understanding.



Images from left: Polymeric pillars of 1 μm diameter fabricated by combining self-organisation and etching techniques; High speed capture of 20 μm wide liquid drops; 500 μm wide microfluidic channels. Background: Self-organised 5 μm diameter pores in polystyrene. Credit: Ronan Daly

International policy workshops

IfM is working with the UK Government to run a series of international workshops at which senior government, agency and industrial representatives from the UK – with research input from the IfM – can build closer links with key countries and share lessons and effective practices relating to: manufacturing policy development, manufacturing foresight and manufacturing policy institutions such as technology and innovation centres, national academies and university-industry R&D organisations.

Two workshops have already taken place this year – in India and Japan – and a third is being planned for the US. For more information about these workshops and to read summary reports of the India and Japan workshops go to: www.ifm.eng.cam.ac.uk/resources/reports

Join the STIM Consortium

The Strategic Technology & Innovation Management (STIM) Consortium is a practice-oriented research and networking collaboration between industrial member companies and the IfM's **Centre for Technology Management**. This annual programme, run by Dr Rob Phaal, is in its second year and is gaining significant momentum. This year, nine research projects covered a range of topics including: how technology intelligence is assimilated in decision making, project portfolio selection for pre-commercial investigations and innovation simulation.

If you are interested in becoming a STIM member, there is an open meeting in Cambridge on Wednesday 19th November to define the research programme for 2015. For more details, go to: www.ifm.eng.cam.ac.uk/research/ctm/stim

Developing effective university-industry partnerships

Strategic partnerships are becoming an increasingly important part of the university-industry landscape. Many large companies are consolidating their investments in universities to focus on developing a core set of strategic partnerships. This is one of the **Centre for Science, Technology & Innovation Policy**'s (CSTI) key research themes, the outputs from which will help those involved develop these partnerships more effectively and will support government agencies in designing their funding programmes in this area.

Tomas Coates Ulrichsen and Dr Eoin O'Sullivan ran a workshop which brought together senior leaders and practitioners from universities, industry and government in the UK and US to identify ways in which they can get better at developing mutually beneficial, effective and long-term partnerships. For more information and a report outlining the key findings of the workshop, go to: www.ifm.eng.cam.ac.uk/csti

In May, more than 80 industrialists and researchers from across the University of Cambridge met to discuss lessons and insights on how best to manage collaborative research between academia and industry. 'Inspiring research through industrial collaboration' is also one of the Department of Engineering's four strategic themes, led by Dr Tim Minshall, Reader in Technology and Innovation Management and head of the IfM's **Technology Enterprise Group.**

Speakers from Boeing, Dyson, PragmatIC Printing, the John Lewis Partnership and the Department of Engineering described their research partnerships, successes and failures from a wide range of collaboration models. Despite the differing contexts, common messages emerged about the importance of flexibility in order to seize the serendipitous discovery, continuity to build trust and deeply competent teams, and frequent interaction to build a shared understanding of each partner's priorities and imperatives.

Launch of joint UK-India research project on sustainable supply networks

A joint research team from the IfM, the Indian Institute of Technology Ropar and the Indian Institute of Management Lucknow is collaborating on a project looking at engineering-driven sustainable supply networks, funded by the EPSRC and India's Department of Science & Technology (DST). An initial workshop took place in India in April, at which 30 delegates including senior policymakers, industrialists and academics discussed the project's aims and approaches, shared ideas with key institutional practitioners and identified the challenges they face.

Dr Jag Srai, head of the IfM's **Centre for International Manufacturing**, said: "The workshop highlighted the need for new methods to explore how resource efficiency – energy, raw materials and water, and reducing waste – will influence the reconfiguration of product supply chains in different industries and national contexts."

Improving efficiency in manufacturing

The IfM is providing its research expertise to a new UK centre that will help manufacturers become more efficient.

The Centre for Resource Efficient Manufacturing Systems (REMS) has been set up as a collaborative partnership with Teesside University, the IfM's **Centre for Industrial Sustainability** and the Centre for Process Innovation (CPI) in Redcar, part of the UK's High Value Manufacturing Catapult.

The Centre is based at Teesside University and will research and investigate manufacturing processes and supply chains to help companies improve production processes by reducing emissions, saving time, reducing cost and minimising the resources they use. Professor Steve Evans, the director of the Centre for Industrial Sustainability, is on the steering group of the REMS centre.

Inspiring the next generation

Every March the IfM hosts more than a thousand visitors as part of the Cambridge Science Festival. This year was no exception with young and old enjoying displays, exhibitions and hands-on activities such as 'Laser Bunny Hop', designing their own watch straps in 'Watch it Made', visiting the photonics labs, learning about sustainability, creating laser graffiti and listening to Tim Minshall's popular talk: *It's not science fiction: it's just engineering*. The 2015 Science Festival will run from 9 to 22 March.

Tim Minshall inspiring children and their parents at the Cambridge Science Festival

IfM ECS news

New faces in IfM ECS

John Saiz has joined from NASA. He will provide innovation and technology management consultancy and education to energy and aerospace organisations in the United States.

From 2008–13, John was the Chief Technology Officer of NASA's Johnson Space Center, advising the senior leadership team on research and technology development, managing the technology strategy, and was instrumental in developing NASA's Space Technology Roadmaps.

He has most recently worked with a leading multinational oil and gas service company on assignment from NASA.

Dr Karen Smith is the new Head of Sector Development and SME Support Business Unit. Previously, she was the Director of Bioprocess Leadership at the Advanced Centre of Biochemical Engineering at University College London, the Executive Director of Cambridge Computational Biology Institute and Acting Head of the Partnership Group (Research Operations) at the University of Cambridge. Prior to that she was a management consultant working with multinationals, mid-size companies, SMEs and early-stage ventures.

Karen leads a team responsible for developing services to support small and medium-sized manufacturers.

Dr Chris van der Hoven has joined to deliver both consultancy and executive education to multinational companies.

Chris has worked with talented leaders on business critical projects in more than 40 countries. Until early 2013 he was a senior academic at Cranfield School of Management and prior to that was a general manager in one of the world's largest utility companies and the managing director of the UK subsidiary of a project and portfolio consulting firm. He studied for his PhD at the IfM's **Centre for Technology Management** where he explored the role of innovation and technology leaders when planning or reacting to major market, technological or business discontinuities.

Chris is also a research lead for the Centre for Technology Management's Strategic Technology and Innovation Management (STIM) Consortium.

BAE Systems Chairman's Award

IfM ECS has been working with BAE Systems to introduce a 'best practice' approach to planning its future workforce capabilities.

The process anticipates future workforce needs and issues – relating both to specific skills and employment trends more generally – and identifies a set of actions to address them. The process is based on a novel application of roadmapping and is now being rolled out across BAE Systems' Programmes & Support Group and has received a prestigious Chairman's Award for transferring best practice.

IfM ECS: working with industry and government

We have published two new documents outlining some of the services IfM ECS can provide for industry and governments.

Delivering growth through effective innovation and technology management is aimed at companies looking to achieve long-term growth through the development of robust innovation and technology strategies and systems.

Creating the conditions for growth is for policymakers who are supporting national and regional growth in key industry sectors.

For more information about our activities in these areas, go to: www.ifm.eng.cam.ac.uk/services/overview/large/itm and www.ifm.eng.cam.ac.uk/services/overview/government

Government minister meets PrISMS companies

Baroness Stowell of Beeston MBE visited the IfM in her then role of Parliamentary Under Secretary of State for Communities and Local Government. She heard how the PrISMS programme, managed by IfM ECS, helps start-ups and small manufacturing firms develop their business strategy, become more sustainable, and identify the best markets and products for their business.

She met a range of companies including a manufacturer of systems for the broadcasting industry, a precision sheet metalwork manufacturer with more than 100 employees and a silk weaving business.

Baroness Stowell said: "Our aim is to create jobs and support local businesses and these projects deliver on both of these fronts. The businessmen and women I have met today are inspiring examples to us all and I am proud that we can provide support to them through projects such as PrISMS."

PrISMS, started in July 2012 as a three-year programme, aims to provide up to 70 SMEs and 50 start-ups with fully-funded support to achieve sustainable growth. It has become a flagship programme for the European Regional Development Fund (ERDF), which co-funds it along with the EPSRC Centre for Innovative Manufacturing in Industrial Sustainability, ideaSpace, IfM ECS and local councils.

Read more at: www.ifm.eng.cam.ac.uk/services/prisms

Developing an industrial strategy for Yucatán

IfM ECS is working with the government of the state of Yucatán, Mexico to develop its industrial strategy. The project is led by Dr Carlos López-Gómez, Research Associate at the IfM's Centre for Science, Technology and Innovation Policy, and its aim is to define the state's strategic options for industrial growth, job creation and the improvement of its competitiveness as a manufacturing location.

IfM ECS is supporting the development of this strategy by facilitating a collaborative process between government, industry and academia. The collaboration builds on IfM expertise in industrial policy, international manufacturing and technology management and will lead to the formulation of an industrial development vision for Yucatán. The project will articulate Yucatán's value proposition as a strategic manufacturing location, identify key areas of opportunity and generate roadmaps for each of them.

A UK roadmap for robotics and autonomous systems - one of the 'eight great technologies'

Robotics and autonomous systems is an important technology providing a common platform for a number of key sectors, and it is one of the UK Government's 'Eight Great Technologies'. IfM ECS was asked by the TSB's Robotics and Autonomous Systems (RAS) Special Interest Group to facilitate a roadmapping exercise across three key sectors bringing together market, user and technology perspectives in: transport and monitoring, health and domestic, and manufacturing and logistics.

The roadmap identified shared opportunities for value creation and capture across these three priority application areas and found common themes which will inform the RAS strategy. This is the third of the eight technologies IfM ECS has roadmapped, having previously tackled Synthetic Biology and Regenerative Medicine.

Become an IfM member

The IfM has two membership schemes which aim to build closer, long-term relationships between companies and our wide range of expertise, and to provide tailored support.

Corporate membership: for access to research-based strategic, technical and business expertise, geared to the needs of large international companies.
Company membership: for access to strategy and capability development for small and medium-sized companies, plus discounts on IfM services, training programmes and workshops.

For more information, go to: www.ifm.eng.cam.ac.uk/membership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DIAL B for Boeing

Duncan McFarlane, Professor of Industrial Information Engineering and head of the IfM's Distributed Information & Automation Laboratory (DIAL), and members of his research team have been working with Boeing since 2005, finding intelligent solutions to some challenging industrial problems.

Boeing is the world's largest aerospace company, producing tens of billions of dollars-worth of commercial jets and defence systems for customers around the world. DIAL is the IfM's Distributed Information and Automation Laboratory, which specialises in using data more intelligently within factories and across the supply chain to develop more dynamic services and smarter products.

Over the last nine years, DIAL has worked with Boeing on six major projects addressing three key challenges: how to manage supply chains more effectively, how to improve resilience and how to make airports more efficient. While these projects have addressed various aspects of Boeing's business they have one important thing in common – a commitment to applying research to solve real-world problems. For Boeing, funding research is all about achieving competitive advantage. For DIAL, it is all about finding solutions which have a significant – and widely applicable – industrial benefit.
These complementary aspirations underpin the relationship between DIAL and Boeing and is neatly illustrated by two of their current projects: ALADDIN (Achieving Leveraged Advantage from Distributed Information) and DisTAL (or Disruption Tolerant Automated Lean Factories).

Letting the genie out of the bottle: making data smart

ALADDIN is a collaboration with Boeing's Research & Technology team, looking at how the vast amounts of data Boeing deals with on a daily basis can be turned into a more valuable commodity for the business. Every time a Boeing 787 takes off it generates roughly half a terabyte of data. While some of it will be critical to the operation, much of it is not.

ALADDIN is particularly interested in the data associated with procurement which suffers from high levels of inconsistency, with the same part often described in a multitude of different ways by Boeing's many hundreds of suppliers. In a fast-paced manufacturing environment, this inconsistency has the potential to cause problems with shortages and disruptions which can only be averted by labour-intensive (and, therefore, costly) data management processes. But this could be avoided altogether if the data were intelligent enough to 'have organic awareness of its own value' and be able to predict potential problems. The associated benefit would be that the many people who currently spend their time sifting through and improving data could be deployed on more strategically useful tasks.

"ALADDIN represents a paradigm shift for us at Boeing: with the completely new and innovative industrial data management ideas and technologies developed by DIAL, many of our day-to-day data issues – which disrupt our operational staff – will be a thing of the past."

Bill Krechel, Technical Lead Engineer in Production System Technology for Boeing Research & Technology, explained: "ALADDIN represents a paradigm shift for us at Boeing: with the completely new and innovative industrial data management ideas and technologies developed by DIAL, many of our day-to-day data issues – which disrupt our operational staff – will be a thing of the past."

While this project is tackling what Bill describes as a 'Cambridge-hard' problem it is by no means a theoretical or speculative exercise. Every project that the Boeing Research & Technology team works on needs to have operational relevance to internal customers who are actively involved in defining and shaping the research output so that the resultant technology can transition into the applicable production environment. For ALADDIN, it is Boeing Defence UK and Boeing Commercial Airplanes who are supporting the project and anticipating usable results. As Philip Woodall, Senior Research Associate in DIAL and lead researcher on ALADDIN, emphasised: "At the end of the project the Cambridge team will be handing over working applications using real datasets, not research prototypes."

The right amount of resilience

Like ALADDIN, the DisTAL project runs under the auspices of Boeing's research team but also involves a direct collaboration with Boeing's Interiors Responsibility Center (IRC) in Everett, Washington where the interiors of all models of Boeing aircraft are designed and built. One of the challenges the IRC faces is that the interiors of planes are highly customised, with each of Boeing's airline customers having its own branding, and often with different branding for different routes. And the specification of interiors is becoming more and more sophisticated as new technologies emerge and airlines become more attuned to the psychological and physiological effects of flying. The ceiling of the new 787, for example, comes with blue LED lighting to mimic the sky and when the plane is approaching its destination the cabin lights turn from the purples and oranges of a sunrise to yellows, and eventually to white against the blue sky.

Professor Duncan McFarlane
Email: dm114@cam.ac.uk

Boeing's 787 factory in Everett © Boeing

These techniques are designed both to soothe passengers during the flight and mitigate some of the effects of jet lag. But, of course, all these developments bring with them new levels of complexity in the production process and the increasing use of specialised composite materials which in the airline industry also need to be strictly controlled to comply with safety regulations.

"Efficient manufacturing operations are really a matter of balance. I believe the IfM can develop formal methods to help us determine those balance points where small additions of capacity or inventory will make our operations much more resilient to disruptions."

The IRC factory runs on 'lean' manufacturing principles but finds that variability in the composite components can cause disruption to the production line. Alan Thorne, who manages DIAL's automation laboratory at the IfM, and who, along with Duncan McFarlane, is heading up the DisTAL project, explained: "Lots of companies implement lean but when you 'lean' a process and have product variability you can become very vulnerable to disruption. The trick is to find the right balance between being lean and being resilient."

Craig Battles, Boeing's Technical Fellow of Robotics and Automation agrees: "Efficient manufacturing operations are really a matter of balance. I believe the IfM can develop formal methods to help us determine those balance points where small additions of capacity or inventory will make our operations much more resilient to disruptions."

In the first year of the DisTAL project, Duncan and Alan spent a lot of time in Seattle to understand first-hand the types of disruption the factory was experiencing and their underlying causes. They used their well-established disruption analysis tools to pinpoint the issues and identify which products and processes were causing problems. They brought these findings back to Cambridge in order to design and structure the next phase of the research process, looking at more intelligent production control systems that will tolerate higher levels of product variability and which can also dynamically alter the balance between lean and resilient operations to cope with disruptions.

Boeing 787 interior © Boeing

This phase of the research is now underway and has informed recent developments to DIAL's automation laboratory. The lab has been reconfigured to provide an industrial strength test-bed for DisTAL which will allow the team to explore and evaluate their new production control concepts using parts they have produced in the lab with different quality defects.

From the IfM's perspective, one of the additional benefits of its work with Boeing is that it gives the undergraduate MET (Manufacturing Engineering Tripos) students an opportunity to get some invaluable hands-on experience, working on very real and very challenging industrial problems. There are currently two student projects tackling aspects of the DisTAL project, one of them concerned with offline programming of robots and the other with understanding the costs of reconfiguring production control code.

With ALADDIN getting ready to start the process of 'transitioning' the research results to Boeing and with DisTAL research well underway, DIAL is already gearing up for two new projects. The first brings together some of the concepts underpinning ALADDIN and DisTAL by using intelligent data to predict when suppliers will fail to deliver on time so that Boeing can take pre-emptive steps to avoid potential disruption. The other is looking at the future of airport operations and how they can address the challenges posed by ever increasing numbers of flights and the demand for more bespoke services when airports' capacity is constrained and their service providers are leaner than ever.

For Duncan McFarlane the benefits of the collaboration are clear: "Working with Boeing is challenging yet simple. Their support for research, operations and administration makes setting up, executing and transitioning research programmes a most rewarding process."

Dr Philip Woodall
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Alan Thorne
Email: ajt28@cam.ac.uk

"Manufacturing is changing. Factories still matter, the production process still matters but manufacturing is now just one part of a much broader range of services companies can offer their customers."

Making the shift to SERVICES

Making the shift to services

Professor Andy Neely, Director of the Cambridge Service Alliance and the Royal Academy of Engineering Professor of Complex Services at the University of Cambridge, reflects on some of the key trends in servitization and the strategic choices facing today's manufacturers.

Professor Andy Neely
Email: adn1000@cam.ac.uk

In recent years we have seen the emergence of five key trends underpinning the transition to more service-based business models. These trends can be characterised in terms of shifts: from a world of products to a world which includes solutions; from outputs to outcomes; from transactions to relationships; from suppliers to network partners; and from firms to ecosystems. This is not intended to suggest that solutions will replace products, or that relationships will replace transactions, but rather to highlight the fact that solutions are supplementing products, relationships are supplementing transactions, and so on.

Customers don't want to buy a piece of hardware that they have to integrate with separate software and infrastructure. They want solutions that are ready to go.

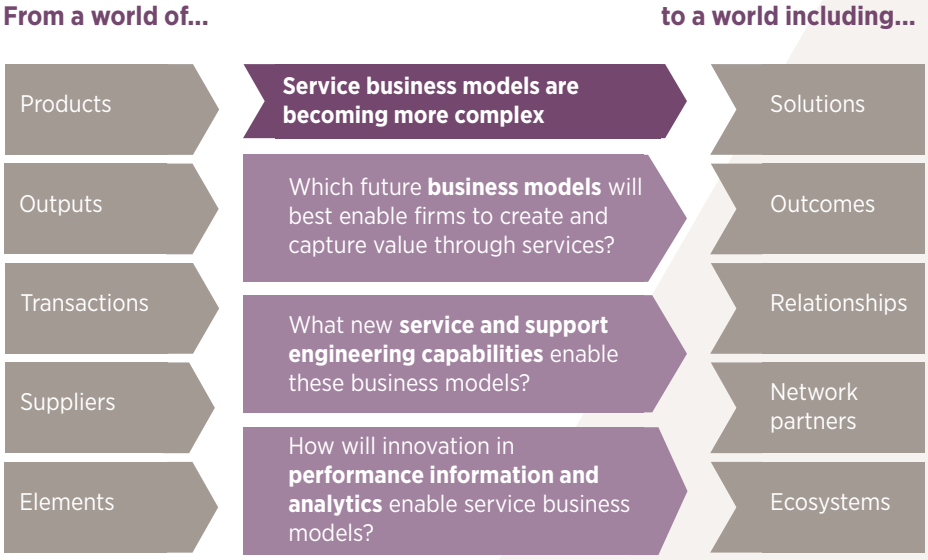
The first trend – the shift from products to solutions – reinforces the fact that customers and consumers are increasingly interested in the solution provided, not just the product. This is particularly acute in the business-to-business and business-to-government arena, where customers are looking to their partners to provide integrated, often technology-enabled, solutions that meet their needs. Customers don't want to buy a piece of hardware that they have to integrate with separate software and infrastructure. They want solutions that are ready to go.

A related shift is from output to outcomes. There are customers who want to 'contract for outcomes'. They define the result they want and then ask a solutions' provider to deliver it for them. In the UK, for example, the government has recently privatised some of its prisons. Included in the contract is an incentive scheme which means the providers are paid more if the reoffending rates of prisoners leaving their care are lower than the national average. The advantage of this approach is that the solutions' provider and the customer share the same incentive – they both want to reduce reoffending rates among the prison population.

Solutions' providers who contract for outcomes often need to make significant investments in building the capability needed to deliver integrated solutions. This, coupled with the fact that risk is often transferred from customer to solutions' provider, means that many of the outcome-based contracts are long term. Extended contract lifetimes are often needed to justify the investment required to establish the capability to deliver the solution. Hence, the third shift – from transactions to relationships. Increasingly, outcome-based contracts involve close and long-term working relations between customers and providers.

The fourth trend – from suppliers to network partners – arises from the complexity of some of the solutions. It is rare that a single firm has all of the capabilities needed to deliver complex services. In the UK defence industry, for example, BAE Systems runs Portsmouth naval base. It maintains and repairs ships, but as part of its contract with the Ministry of Defence, BAE Systems is also responsible for maintaining the physical infrastructure of the docks, and for providing support services for sailors and their families including accommodation, leisure facilities and catering. It also coordinates the entire fleet support programme. Some of these services are core to BAE Systems, but others – catering, for example – are not. BAE Systems, therefore, partners with other organisations to deliver specific elements of the service package. And it is not just non-core services that are outsourced by the prime contractor in complex services. Integrated solutions are often enabled by sophisticated technology and software infrastructures, including significant elements of data analytics. The prime contractor may well partner with specialist software developers and data analysts to deliver the service. The point is that we are increasingly seeing networks of organisations pooling their capabilities, rather than operating in the traditional buyer–supplier mode.

The graphic below describes the final shift as being 'from elements to ecosystems'.



Describing the shift to services

This transition is concerned with the changing nature of industrial competition. Instead of individual elements (in other words, firms) considering how they can compete with their direct competitors, they are making strategic choices to shape the ecosystem they operate within. Apple, for example, has opened up the technology for creating apps, which has encouraged lots of people to become apps' developers. Yet Apple still owns the platform – the hardware and the App Store – which allows users to access the apps. By encouraging the proliferation of apps' developers, Apple creates competition in one part of the ecosystem.

This intense competition makes it difficult for the developers to charge very much for their apps, which means that Apple consumers can access a wide range of low-priced apps through the Apple platform. The wide range of apps is of value to Apple consumers who, in turn, are willing to pay high prices for the Apple-designed hardware needed to access the apps. So by creating competition in one part of the ecosystem, Apple has managed to create additional value for the users of their products, which in turn increases consumer loyalty to the Apple range. Across many industries the competitive choices are now not simply about how firms compete with their direct competitors; what matters is how they seek to shape the industrial ecosystem to their advantage.

These five trends underpin the strategic choices manufacturers need to make about the kind of service provider they should become. One of the questions they must ask themselves is: where does value lie and when is it realised? In traditional manufacturing, the value lies in products and parts – the physical assets – and value is realised at the point of sale, when the customer pays for the product. Many manufacturers, particularly those who make products with long life-cycles, have recognised that value can also be realised throughout the life of a product, especially when products need repair and overhaul. Such firms have a strong focus on the 'aftermarket', and derive significant value from the sales of 'spares and repairs'.

Another approach is to embrace the trend from products to solutions, putting the emphasis on the outcomes the customer wants, rather than on the physical product. The old Theodore Levitt quote "customers don't want quarter-inch drills, they want quarter-inch holes" illustrates the point. Many customers don't want to own the

Across many industries the competitive choices are now not simply about how firms compete with their direct competitors; what matters is how they seek to shape the industrial ecosystem to their advantage.

physical products that manufacturers provide – they just want the end result (or the outcome) that the product delivers. When manufacturing firms become more focused on outcomes they often 'contract for capability', guaranteeing uptime and/or the availability of their equipment through life. Rolls-Royce, in its aero-engine business, contracts for Power-by-the-Hour, effectively selling the thrust the engines deliver rather than the engines themselves. A significant advantage of contracting for capability is that the incentives of the customers and the original equipment manufacturers are aligned. If companies are deriving significant income from 'spares and repairs', it suits them if the equipment breaks down. When contracting for capability or outcomes, however, the manufacturer gets paid only when their equipment is working, so it is in their interest to make their equipment as reliable as possible – which also suits their customers.

One of the challenges of contracting for capability, however, is the issue of risk. If manufacturers take responsibility for the outcomes their products deliver – effectively guaranteeing results for their customers – they are taking on significant risk. Some servitizing manufacturers have decided that the risk is too great. Equally, some customers have decided they don't want to relinquish control over outcomes to a third-party, so prefer not to enter into this kind of contract.

There is also a third way: selling knowledge and insight, recognising that value lies in the solution the original equipment manufacturer offers. Think here of manufacturers who offer design and development or installation advice. Think of those who have moved into training and consultancy services. They no longer simply sell products. They also sell knowledge and insight.

So manufacturers who are considering the shift to services have three broad strategic choices to make: whether to focus on the aftermarket or on delivering outcomes or on supplying knowledge. These choices, however, are not mutually exclusive. Manufacturers can decide, for example, to focus both on the aftermarket and on knowledge support, although clearly the different positions will require different organisational capabilities.

These trends and choices can have profound consequences for manufacturing firms. And, of course, profound change results in significant challenge. Not all firms find it easy to make the shift to services and this is one of the reasons why the Cambridge Service Alliance was established. Working with our partners, BAE Systems, Caterpillar, GEA, IBM, Pearson and Zoetis, we are actively exploring how firms can successfully make the shift to services, by innovating their business model, building the right organisational capabilities and exploiting the power of data, information and technology.

Find out more

The Alliance publishes a wide range of reports, working papers, executive briefings, case studies, videos and podcasts on service-related topics. Find out more at: www.cambridgeservicealliance.org

CAMBRIDGE **SERVICE WEEK**

This is an annual series of events hosted by the Cambridge Service Alliance which brings together leading academics, industrialists and policy-makers to address the evolving challenges facing service education, research, practice and policy. The theme for the fifth Cambridge Service Week, held at the end of September, was the 'Future of Services in a Digital Age'.

The lost art of risk management

Dr Mukesh Kumar from the Centre for International Manufacturing suggests that multinational manufacturers are taking unnecessary risks with their industrial investments – and he offers a solution.

Industrial investment is getting riskier. Globalisation has brought with it a wealth of opportunities for multinationals, such as access to low-cost labour and new markets, but it also has its downsides. Companies find themselves navigating a dynamic and unpredictable business environment and exposure to continuous change increases risk – both in maintaining global operations and in managing industrial investment. At the Centre for International Manufacturing, we have studied some of the world's largest manufacturing companies and concluded that while they recognise the need to manage their risk more effectively, they do not have rigorous processes in place to identify, assess, manage and monitor the risks associated with investing in new projects.

Since the banking crisis in 2008, the world has woken up to the consequences of unregulated risk. Managing risk is now a major issue for corporate finance and governance and real progress has been made in understanding and articulating financial risk. However, there seems to be little evidence that the risks associated with the globalisation of manufacturing are being systematically managed, even though an ill-advised internationalisation project can jeopardise a company's future. What appears to be happening is that companies are applying some of these new instruments of financial risk analysis to their global manufacturing investments. But these are complex tools designed for a different job and they can distort the fundamentals of risk management by failing to take account of the risks that are particular to manufacturing.

One of the main causes for concern is that companies seem to manage risk through a variety of methods, none of which has been designed specifically for the task. And while some of these methods are explicit, many are implicit, and all tend to be embedded within the company's regular strategic and financial planning and evaluation processes. There is, in fact, no generally recognised comprehensive and systematic approach to analysing and mitigating the risks associated with industrial investments. In addition, risk management is usually carried out at the corporate level which tends to categorise risks quite broadly and may fail to consider the full spectrum of risk to which the company's global operations may be vulnerable. This means that too few risks are being identified and those that are, are not being evaluated objectively. Too great a reliance on non-scientific methods of risk quantification also means that their assessment of the magnitude and likelihood of risks is often based on assumptions and the consequences of accumulated risk are not taken into account.

"There seems to be little evidence that the risks associated with the globalisation of manufacturing are being systematically managed, even though an ill-advised internationalisation project can jeopardise a company's future."

Other weaknesses in risk management are associated with organisational structures and cultures. It is often unclear who within the organisation has responsibility for particular kinds of risk. And even when people or teams do take ownership, they face the challenge common to all highly complex multinational organisations – the difficulty of sharing knowledge across functions which may be scattered across different sites around the world.

How can we help companies do better? It is clear from our research that companies need a formal, systematic process for risk management that has been designed specifically for global manufacturers. But first, we need to think more clearly about how we classify risk. The top-level view of risk is based on three broad categories: organisational, operational and external risk. Organisational risk relates to corporate strategy which, although it may have little apparent impact on individual investment projects, if something does go wrong the consequences for the project are likely to be significant. Operational risk relates to the complete set of activities which takes place across the value chain – project management, R&D, procurement, production, distribution and sales and marketing. In other words, any activity that can generate value for the company is also subject to risk. External risk relates to those economic, political and environmental shocks which may be difficult to predict but should, with the right mitigation capabilities in place, be possible to withstand.

These three types of risk are all connected. A risk in one area is liable to precipitate risk in a number of others. External economic slowdown, for example, can trigger a risk for production and for sales and marketing. Similarly, problems with the quality of raw materials – another external risk – create risk in procurement which in turn affects production, sales and marketing and after-sales service. So we could, in theory, develop a list of potential risks to help with classification. However, because risk is not static this can produce misleading and incomplete results.

Two Backgammon Players, from the *Book of Games, Chess, Dice and Boards*, 1282 (vellum), Spanish School

Instead, by using a typology of industrial investment risks, companies can focus on the sources of risk in order to identify the specific risks to their project.

Having better understood how to classify risk we can develop a more rigorous process for risk management. And we have been doing just this, bringing together our research findings to develop a systematic approach to risk identification, assessment, administration and monitoring. For each of the following steps we have developed a set of structured approaches and analysis tools:

Identifying risk: first, you need to identify what changes to the business the project is likely to cause and categorise those changes. This then forms the basis of the risk analysis, looking first at how the project will affect generic risks and, from that, identifying specific risks. The specific risks should then be considered in the context of the investment objectives and potential changes to the network in order to build a qualitative rationale for prioritising risks. At the end of this first step, you should have a clear understanding of the key risks for your investment.

Assessing and managing risk: the second and third steps are connected. Once you have established the key risks, you can review them using probability and impact assessment tools. Only then can you develop appropriate risk mitigation capabilities at the operational network and project levels. When these are in place, you need to reassess your risk, taking your new risk mitigation capabilities into account. At this point, you should also go back to your financial investment valuation model to take account of the revised risk and develop scenarios based on your new risk mitigation capabilities.

Monitoring risk: Once under way, the project needs continual monitoring using both risk and risk mitigation capability indicators. By systematically reassessing risk, mitigation capabilities can be adjusted as the risk assessment changes. A structured approach of this kind also supports integration with other investment projects so that risk can be monitored at the project portfolio level.

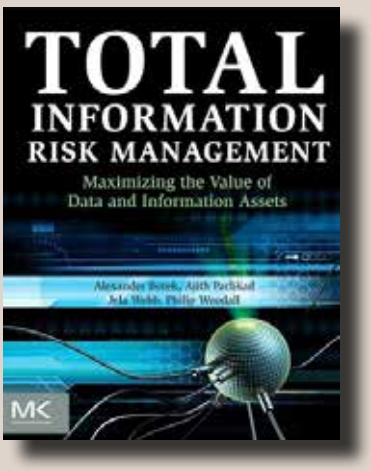
A systematic approach to risk management which has been designed specifically for industrial investment has several important benefits. Say you were to consider investing in a high-return oriented plant to manufacture product X using technology Y at a particular geographic location. This approach could tell you if the risk will outweigh the expected return, taking account of the risk interdependencies and the cost of putting in place mitigation capabilities. None of the traditional approaches to risk management used by multinationals would be able to arrive securely at that conclusion. As well as helping companies improve their risk management, the approach also provides better risk reporting for regulators, investors and auditors.

Most global manufacturing process improvement programmes are limited to capability and development and performance measurement and the notion of 'risk' and 'risk management' tends to be mentioned in a somewhat cavalier manner. This approach puts risk and risk management at the heart of the global manufacturing process.

Dr Mukesh Kumar's main research and practice interests are in the areas of risk and resilience in emerging and developed industrial systems. Before joining the University of Cambridge, he worked in the financial sector as a senior analyst and corporate finance consultant.

To find out more about Mukesh's research in this area, contact him at: mk501@cam.ac.uk

A risk management approach to information



Alexander Borek, *Data Scientist at IBM*
Ajith Parlikad, *Deputy Director of the Distributed Information and Automation Laboratory, IfM*
Jela Webb, *Senior Lecturer at the University of Brighton*
Philip Woodall, *Senior Research Associate, Distributed Information and Automation Laboratory, IfM*

How well does your organisation manage the risks associated with information quality? The increasing sophistication of IT capabilities along with the constantly changing dynamics of global competition are forcing businesses to make use of their information more effectively. Information is becoming a core resource and asset for all organisations but it also brings many potential risks to an organisation: strategic, operational, financial, compliance, environmental and societal. This book provides you with the fundamental concepts, guidelines and tools to ensure core business information is identified, protected and used effectively, and written in a language that is clear and easy to understand for non-technical managers.

Paperback	ISBN 978-0124-05547-6	£30.99	316 pages
Ebook	ISBN 978-0124-05861-3	£30.99	
Elsevier			

New business models for a sustainable future

Dr Doroteya Vladimirova from the Centre for Industrial Sustainability contends that manufacturers need to start doing business differently if they are to create value for themselves and for society as a whole – even if that means working with some of their competitors. »

New business models for a sustainable future

The interconnected nature of the world today means that local disruptions can have global repercussions. Financial crises, extreme weather conditions, social calamities from near and far have an impact on even the most affluent nations. And increasing competition for finite resources, volatile commodity prices and climate change mean that manufacturers will be forced to do business differently in the future.

At the Centre for Industrial Sustainability, it is our job to worry about the future. The increasingly urgent need for companies to do things differently and responsibly, and for them to embrace a long-term view of prosperity has informed three areas of our research: what do we mean by 'value' in the context of sustainability, how can we develop more sustainable business models and how can we experiment with business model innovations in a risk-free environment.

At the Centre for Industrial Sustainability, it is our job to worry about the future.

What is 'value' for sustainability?

Organisations talk about 'value' all the time, but what do they really mean by it? Defining value has been a source of contention since Plato and Aristotle and even after 2,000 years of discussion, its meaning continues to evolve. Economic philosophers and scientists made Adam Smith's view of 'value' the cornerstone of economic thought and it is this view which largely prevails in today's business practice. However, more recent debate has seen a shift from Smith's 'exchange value' to thinking more in terms of 'value-in-use', as manufacturers move towards more service-based business models with a stronger customer focus. Most recently, Michael Porter and Mark Kramer have been writing influentially about the concept of 'shared value', suggesting that economic value should be created in a way that also creates value for society by addressing its needs and challenges.

So, what do *we* mean by value in the context of sustainability? Our Centre's view on what constitutes 'sustainable value' is: *the well-being, improvement, continuity and preservation of the individual (human life), company, society and environment, in such a way that satisfies the needs of the present without compromising inter-generational equity*. It has three components:

Sustainable economic value which includes growth – profit, return on investments, financial resilience and the long-term viability and stability of the business.

Sustainable social value which includes poverty alleviation, social justice, equality, well-being, community development, long-term employment, secure and meaningful livelihoods, labour standards and practices, wages, code of conduct, career development, health and safety and diversity.

Sustainable environmental value which encompasses the use of resources at a rate at which they can be renewed, ensuring that emissions and waste are at a level that can be metabolised safely by the environment, protecting bio-diversity and creating positive benefits for the environment to counter past excess.

We need business models that can reconcile how a company can create and deliver value for its multiple stakeholders while capturing value for itself.

What are sustainable business models?

Having a clear definition of 'sustainable value' is important when we start thinking about sustainable business models and what they might look like. We need business models that can reconcile how a company can create and deliver value for its multiple stakeholders while capturing value for itself. However, the changing resource landscape creates opportunities for innovation. The challenge is to rethink the manufacturing industry as a network of complex and evolving relationships, and to understand the changing pattern of the movement of value and the value creation among the network actors.

Collaboration in business may seem counter-intuitive to competition. However, several highly competitive sectors such as automotive, furniture and FMCG are working together in order to achieve energy and resource efficiency. Companies such as Xerox, Kingfisher, British Sugar, Unilever, Marks & Spencer, Vitsœ, Toyota, Riversimple – to name but a few – are engaged in innovative and disruptive cross-sector initiatives for sustainability. These kinds of activities involve significant changes to overall business processes, resource flows and activities – both at the company and network level. The research suggests that it is helpful if those involved take a holistic approach to redesigning their business models using a 'shared value' perspective.

Our tools enable organisations to work together in ways that increase value and reduce resource and energy demand and deliver positive social impact.

Better models in business models

Research and practice on business model innovations to support industrial sustainability are developing rapidly in areas such as product-service systems, closed-loop business models and industrial ecology. However, there is still relatively limited understanding of how manufacturers, consumers and other stakeholders need to behave in order to support successful innovation for sustainability.

Naturally, companies want to be able to predict how their actions will affect the value they create. But in order to do this, they need to be able to manage information from the complex network they operate within and do so throughout the lifecycle of their products. This means taking account of all network stakeholders, including suppliers and partners, customers, investors and shareholders. At the same time, all business relationships include not only formal contractual activities but also informal exchanges of information and benefits. Identifying *all* the value flows within a network can reveal opportunities for innovation and improvement. The challenge then is how to envisage and design the right future business model.

Which takes us back to our third area of

research activity: how to experiment with business model innovations in a risk-free environment. We are doing this by developing new business modelling tools which analyse and illustrate the movement of value in order to identify practical and profitable opportunities for business model innovation. Our tools also enable organisations to work together in ways that increase value and reduce resource and energy demand and deliver positive social impact. Our ultimate goal is to give organisations the tools to create their own transformation pathways to new, more sustainable business models and enable them to enter new collaborations which will result in a significantly higher level of sustainable business performance and organisational health.

The growing recognition that current industrial practices cannot be sustained in the long term brings challenges, opportunities and hopes for both industry and academia. The expanding perception of 'value' beyond its economic monetary meaning and business models which treat the natural environment and society as equal stakeholders of the company are slowly becoming part of our reality. The task is to reduce the uncertainty and risk to allow such changes to be widely adopted. We have a difficult job ahead of us but today is the time to invest into the future.

If your organisation would like to experiment with new more sustainable business models, contact:
Dr Doroteya Vladimirova
Email: dkv21@cam.ac.uk

At the Centre for Industrial Sustainability, we are working on a number of business model innovation projects with industry partners, including:

Redress is a project with Marks & Spencer, funded by the Technology Strategy Board, looking at how business model and supply chain innovation can drive garment recovery and retained value. It also seeks to accelerate Marks & Spencer's Plan A commitments to reducing waste by trying to decrease the environmental impact of raw materials in its clothing supply chain. The outcomes of the project can be applied to textile and other sectors.

The **Business Models for Sustainable Industrial Systems** project is funded by the Engineering and Physical Sciences Research Council (EPSRC) and aims to develop a novel way of helping companies find and visualise opportunities for business model disruptions and innovations that result in more sustainable businesses. Agent-based modelling techniques will be applied to unravel complex behavioural characteristics and contexts that have the potential to disrupt the current business model. The team will develop an ICT business modelling tool to help companies understand, design and test new business models through rich visual simulations.

Dr Doroteya Vladimirova is a lead researcher at the EPSRC Centre for Industrial Sustainability specialising in strategic change and transformation towards new business models. Her focus is on transformations from products to product-service systems and business model innovations which lead to more sustainable organisations.

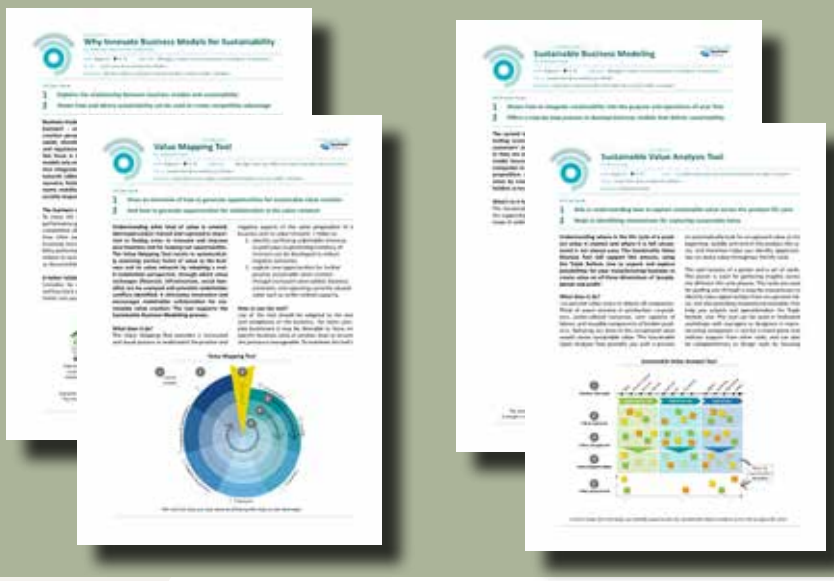
The Centre for Industrial Sustainability is the lead research partner in the EPSRC Centre for Innovative Manufacturing in Industrial Sustainability, along with Cranfield University, Imperial College London and Loughborough University.

Quick guides to industrial sustainability

A set of 'Quick Guides' is available for download from the EPSRC Centre for Innovative Manufacturing in Industrial Sustainability website at: bit.ly/CISquickguides

The Quick Guides aim to make the knowledge generated by the researchers in the Centre accessible for industry and businesses.

They are clustered around three main themes: sustainable business models and strategies, eco-efficiency and processes and eco-factories.



Innovation by design

Linde Gases has designed a radical new valve for its gas cylinders, with support from the IfM's Design Management Group and IfM ECS.

Linde Gases is part of The Linde Group, a world-leading gases and engineering company with more than 63,000 employees based in more than 100 countries and with revenues of in excess of €16bn a year. In 2011 its industrial gases division faced a product development challenge within its 'packaged' (or cylinder-based) gases division. With approval and direction from the Linde Executive Board, the Linde packaged gases team was asked to develop a new, innovative and market-leading valve design for their gas cylinders.

The new valve was to not only improve upon the company's existing valve offerings and combat any competitive threat; the ambition for it was to redefine the possibilities of valve design and so further strengthen the Linde brand. While the team perceived this to be a unique opportunity, it was faced with limited internal capability for the task. Since then Linde has developed a collaborative, long-term relationship with the Institute for Manufacturing (IfM) and its knowledge transfer arm, IfM Education and Consultancy Services (IfM ECS), to help it address this issue.

Colin Haden, Head of Centre of Excellence, Packaged Good Products at Linde, explained: "When the various teams across our business units started to look at the valve strategy, we recognised that there had not been enough focus on valve innovation in recent years and that any new valve patent would have to be a significant leap from the last one."

Addressing this deficit was not straightforward. The gases division of The Linde Group had grown significantly through acquisition, having bought the Swedish gas company, AGA, in 2000 and the British BOC Group in 2006, adding a layer of complexity and regional variation to existing valve design which initially masked the scale of the challenge. In addition, Linde, along with its competitors, operates in a highly regulated market so any radical design departure would need to undergo high levels of scrutiny to ensure safety compliance as well as delivering functionality.

The first step was to create a 'task force', drawing from a wide range of disciplines and backgrounds from the company's regional business units, including technologists, procurement, sales and marketing. The task force then enlisted the help of IfM ECS to develop a technology roadmap, starting with a broad sector landscape which provided the context from which they could drill down to individual topic roadmaps, including one for valve development.

A new approach to product design

Colin explained: "Two significant things happened that day. The team created a roadmap for valve evolution which everyone bought into and we had a presentation from Dr James Moultrie. James is Senior Lecturer in Design Management at the University of Cambridge and he introduced us to a range of tools and techniques that underpin good product design. He inspired us to think in completely new ways about the new valve design specification and to develop new approaches to achieve it."

James added: "I encouraged them to consider the whole product platform and establish a long-term plan for their valves that would enable them to develop a range of products based on a set of core technologies. I also emphasised the importance of combining excellence in technology with professional industrial design skills."

At their next meeting, James, with the support of IfM ECS colleagues, helped the task force to brainstorm innovative approaches to new product design. This led to a decision to run a competition in which design agencies would present their ideas.

From a long list of candidates, 15 design companies were shortlisted and their concepts brought to the IfM for review by the task force. It was agreed that no single company had delivered a complete solution, so the team elected to take the best design, technology and manufacturing elements from the various proposals to develop their own specification. A project team was set up and external companies selected with expertise in design, technology and manufacturing. Under James's guidance, the team approached the collaboration with care, aware that a first-class working relationship between the different parties would be fundamental to the product becoming a commercial success.

Michael Eitel, Head of Global Product Management Packages at Linde, explained: "We appointed external design and technology companies and, initially,

Dr James Moultrie
Email: jm329@cam.ac.uk

used Linde's own production facility in South Africa as the starting point for manufacturing. As the project plan began to roll out we recognised the need for additional manufacturing capability so we approached a manufacturer in Italy who could see the potential of the new design and was keen to be part of the journey. One of the things we learnt from James was the importance of managing these cross-cultural and cross-industry relationships and being very clear about everyone's roles."

A major challenge for the team was to avoid infringing competitors' patents. Adopting a two-stream approach allowed the task force to develop the original design concept while at the same time progressing a new and quite distinct internal structure.

The next challenge was to choose the best materials and mechanism for opening and closing the valve. The industry norm of a 'screw down' mechanism allows for wear to the valve seat and can just be turned a bit further to achieve a good seal. A lever, however, pushes down to a fixed point so if it wears, the valve will not close fully. Overcoming this challenge initially perplexed the valve designers and the development team found themselves back at the IfM for support in reviewing their options.

In the meantime, however, competitors had also identified the valve design gap that Linde had been pursuing and had just introduced a new patent, which necessitated some adaptations to the Linde design. Fortunately, with its two-stream approach, Linde was in a strong position. Having carried out the initial technology roadmap with the IfM, the team well understood the need to be flexible across the life the project. This included an option to pursue a basic, lower-cost valve design or to build in mechanisms which would support future upgrades. With their competitor electing to patent a not dissimilar, lower-cost valve design themselves, this essentially sealed the decision for Linde, setting the team on the road to a higher specification version of their valve design. The new valve would be more expensive for customers, but would work with any platform and provide much greater flexibility for the future.

Setting the standard

Linde has succeeded in its goal of developing a new state-of-the-art valve. Intuitive to use, it has a lever to ensure ease of opening and closing and is safeguarded by a button to release the mechanism. Crucially, it has an innovative integral contents gauge which shows how much gas remains in the cylinder. For both Linde's customers and staff this will have huge benefits, making the delivery and handling process significantly more efficient. The valve's user-friendliness also brings with it important safety benefits by eliminating the temptation to close the cylinder using the external regulator which can result in potentially dangerous leaks.

One of the next-generation needs Linde has already identified is to have a built-in regulator. Regulators are typically attached to the cylinder but in some circumstances, such as when working at height or underground or when requiring high mobility, separate regulator units, even when securely attached, can be problematic. With careful forward planning of the product platform, Linde's new valve is designed so that its structure can accommodate an integrated regulator. Although more costly to manufacture, its obsolescence-resistant design means that Linde will face lower lifetime costs by obviating the need for another new design to support future upgrades in the medium term.

The valve was initially beta tested with customers who rated it very positively and it has been through stringent regulatory testing. It will be launched in several European countries this autumn and can be seen first-hand at the EuroBLECH trade fair in Hanover, Germany in October. It has also acquired a name: EVOS.

Linde expects to use five to six million of the new EVOS valves and, when the time comes, possibly even more of its next generation upgrade.

Colin said: "Linde's innovative new valve is a potential game-changer which may well redefine the industry standard. The IfM and ECS's role has been pivotal to the process. Working with people from Cambridge University has undoubtedly brought a fresh and creative perspective to our product development approach. Often if you engage a large consultancy firm, you can risk engaging multiple consultants and incurring a not inconsiderable bill. Businesses sometimes need a lighter touch and a guiding hand in the right direction. IfM ECS is a real ambassador for such an approach and is a credit to the University."

From smoothies to Star Wars

Georgina (George) Rose graduated with an MEng in Manufacturing Engineering in 2010.

How did you find school?
"I went to an all-girls school where the pinnacle of my future career prospects was seen as going into the City and becoming a banker. I did design and technology at GCSE because I loved it and out of the 26 girls doing it, only six of us took Resistant Materials with the other 20 opting for graphics. My other favourite subject at school was physics which was also hands-on and experiential."

Why did you choose to do engineering at university?
"I was interested in it and wanted to do something that I enjoyed. Having said that, I wouldn't say I was considering it as a career – I still wanted to go into the City to be a banker. But in my final year I applied to innocent and started as soon as I graduated."

Why did you choose MET?
"When I applied to Cambridge I hadn't heard of MET but in my first two years, even though I had been pretty good at maths at school, I found the maths content of the engineering course hard going. In the second year, James Moultrie did a module on design which really sparked my interest and when I started thinking about my third and fourth year options, all the management and process stuff made MET seem so much more exciting and really relevant and applicable to a wider range of future careers."

What were you doing at innocent?
"I was lucky enough to have three different jobs in four years. I started off as an Ingredients Planner, managing the stock levels of the raw materials (by which I really mean fruit!) mainly for our manufacturing partner in Holland. My next job was further down the supply chain as Juice Production Planner, managing the production of smoothies and juices at their production site, ensuring that enough bottles were being filled with the right products to guarantee availability on the supermarket shelves.

My final role was as 'End-to-end Project Manager' in the finance department, looking at how to make cost-savings across the entire value chain, from sourcing the ingredients to sales and distribution."

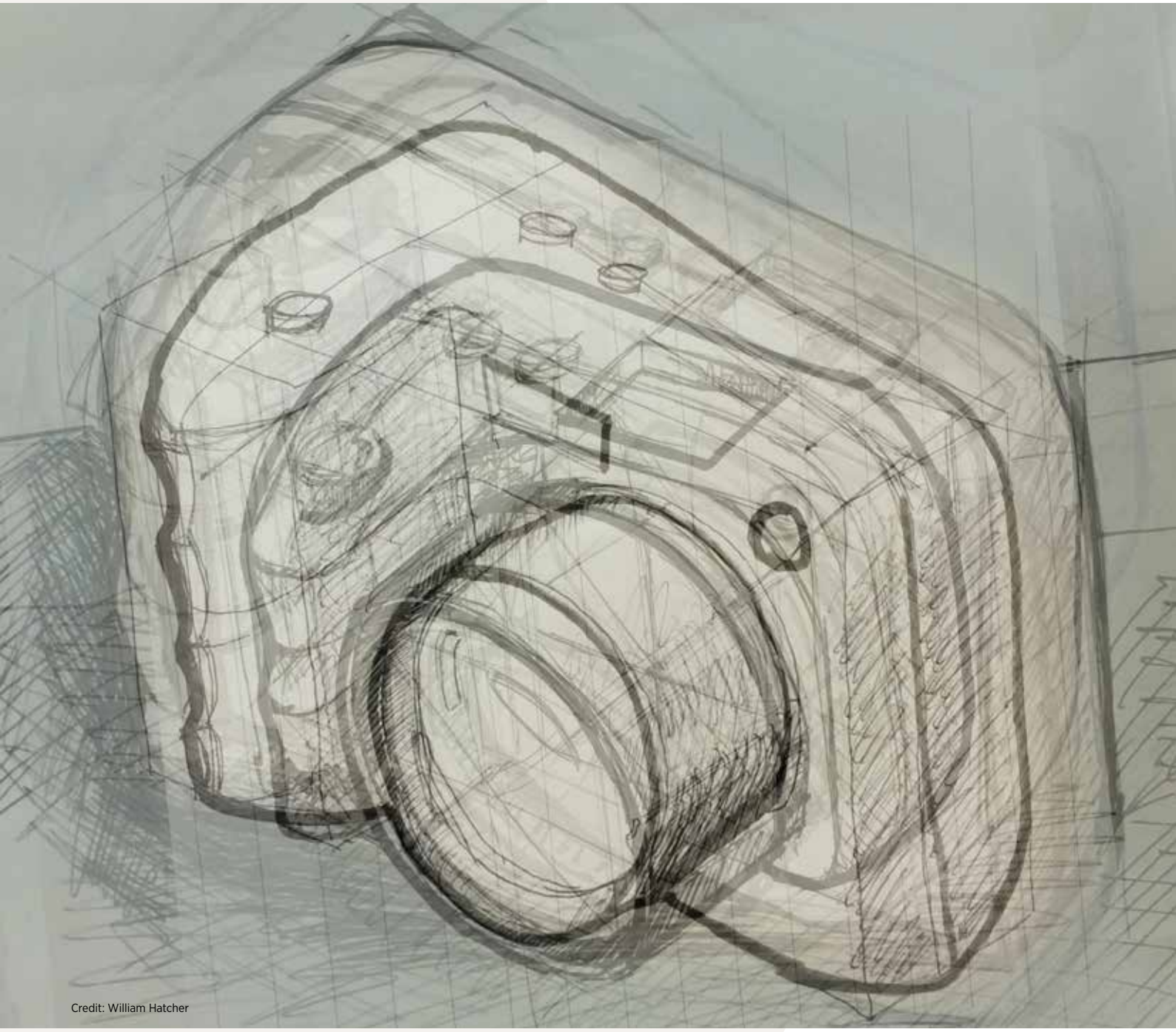
And what are you doing now?
"After much soul-searching about leaving innocent, I decided I needed to broaden my experience and applied to The LEGO Group. So I'm now working at their new European headquarters in central London as one of four managers in the supply and inventory planning team. I've got two roles: I'm Inventory Lead for Europe but I'm also European Supply Manager for the LEGO Technic, Star Wars and castles themes. LEGO is a fantastic place to be with incredible supply chain management and manufacturing processes. And, of course, it's really cool to make the things that kids make things with."

How has MET helped you in your career so far?
"The key skill that I got from MET was problem-solving. A lot of that came from the projects, when we were sent off to a factory, not knowing what we were going to find, and then having to apply our knowledge, first of all to work out what the problem was and then come up with a solution. This has been fundamental to what I've been doing in the last four years. The other massively important skill was learning to work as a team, not just with other students but also with a wide range of people from senior management to people on the factory floor. The course also taught me to constantly look for ways to improve things and add value – even when there is no apparent problem things can always be done better.

When I was working on the cost-savings project at innocent all the value stream analysis and everything I had learnt about 'lean' and 'kaizen' was invaluable and gave me such an advantage over other people who didn't have the same theoretical background.

Choosing MET was absolutely the right decision for me. I loved the course and it has set me on a great career path."

George was in conversation with MET IIB student James Hutchings, as part of his project to develop resources for school teachers. He was creating a prototype website for use in the classroom which connects science themes from the National Curriculum with short, easily accessible examples, cases and videos from practising manufacturing engineers.



Credit: William Hatcher

2014 MET design projects

The Manufacturing Engineering Tripos (MET) course is a programme for third and fourth-year engineering students who have successfully completed the first two years of an engineering degree. MET takes the best engineers and provides them with the management competence, business acumen and interpersonal and organisational skills they need to become world-class leaders.

Over the last academic year, teams of three or four MET students have completed a major design project to develop a new product, with real business potential. Having first identified a customer need, they have researched the market, developed original design concepts and created a full business plan. The projects have generated some exciting new ideas and innovative technology.

MET design projects 2014

FlexiWRIST

FlexiWRIST is a low-cost prosthetic wrist joint that offers significant improvement in the ability to perform daily tasks. Existing upper limb prosthetics are either low-cost and rigid with minimal functionality or very expensive robotic arms that mimic natural movement. By adding a small technological improvement to the design of the wrist joint, large improvements to functionality can be achieved resulting in more natural movement for performing certain tasks. FlexiWRIST aims to provide a more natural passive wrist movement whilst remaining a low-cost and accessible option for upper limb amputees.

Team: **Daniel Brackenbury, Emma Clement, Chris Goodfellow, Stephen Hall**

Hive Aid

Aimed at the millions of people seeking refuge worldwide, Hive Aid shelters provide medium- to long-term solutions which last five to ten years. The cost-effective and rapidly deployable hexagonal design facilitates tessellation to accommodate families and build communities; a vastly underestimated concept in such situations.

The Hive Aid shelter centres on the provision of uniquely designed poles as a framework onto which panels are slotted. Each plastic pole comes from the same extrusion, and has three flexible slots to connect the panels at a range of angles. They are extruded in the UK, then transported to the site alongside other emergency supplies such as food, medication and clothing. The rectangular wall and triangular roof pieces can be sourced locally, as they are designed to be cut simply from any standard sized panel. The remaining material can be joined to make additional roof pieces or used as flooring, to eliminate waste.

Team: Jack Bews, Sam Blackett, Charles Holland, Sasha Nagarajah

Infinity Bakery

Infinity Bakery provides ovens that allow existing bakeries to switch from firewood to solar power. We will partner with micro-financiers to empower groups of entrepreneurs, trained at these bakeries, to set up satellite bakeries.

This will have multiple benefits. Increasing use of solar power eases deforestation, reduces the need to collect firewood, and alleviates health issues associated with smoke exposure. Crucially, it will insulate this low-margin industry against long-term fuel price increases. This means charities can continue to use the establishment of bakeries to support individuals in lifting themselves sustainably out of extreme poverty.

Team: Daniel Cox, William Hatcher, Keno Marie-Ghae, Leyla Sudbury

The Low Cost Bed

This is a bed made solely from cardboard that can be deployed in minutes and provides heat insulation from the ground, as well as improved levels of comfort. The bed is designed for use in homeless shelters in the UK, particularly during winter when bed shortages occur, as many can be stored during the day and placed on the floor at night. It is also designed for disaster relief situations where the immediate needs of people have been met, including shelter, food, sanitation and medication. Here it can provide an additional level of comfort and tackle problems caused by sleeping on damp or hard ground.

Team: Stephanie Brown, Richard Cadman, Jonathan Godden, Tayo Moore

MyPod

Autistic individuals display a wide range of behavioural traits, but one of the most pressing issues for parents and schools to address is an increased sensitivity to external stimuli such a light and sound. This sensitivity means that children with ASD can become easily distressed in working environments that are the norm for most. Research has shown that people with ASD are soothed by pressure, are comfortable in enclosed spaces and like the feel of different textures.

MyPod acts as a portable sensory room and targets a wide range of issues, which are experienced by people with ASD. Its main function is to offer relaxation techniques in the form of rocking and pressure application. The sensory pod can be rocked externally by a teacher or parent, which makes for easy interaction during the calming period. Rocking can also be generated internally, by the users themselves so they can feel independent if they want to.

Team: Joseph Mambwe, Bruno Sussat, Sarah Tong

Piste Pilot

Piste Pilot aims to help those with sight loss enjoy the freedom experienced through sport by providing discreet, safe and reliable guidance devices. Current guidance methods mainly comprise either a continuous physical connection to the guide or verbal directions issued through a microphone and speaker system and are restrictive in terms of the amount and type of information that can be given.

The Piste Pilot is designed to be picked up by a blind skier on holiday with a sighted friend, using an interface that can be mastered quickly. It will be provided as four integrated ski poles – two for the guide and two for the skier with sight loss. The skier will receive vibrations in their ski poles, triggered by a series of button presses from the guide on their own poles. The information given will include direction, how hard to turn and when to start/stop. This will be achieved wirelessly using radio communications.

Team: David Elliott, Christopher Owers, Elizabeth Tyler

PyroCut

PyroCut automatically isolates the power supply in the event of a fire. Once a fire has been detected, there is a three-minute time delay before the power is isolated, to ensure there is sufficient time for the occupants of a dwelling to leave the property, as well as allowing them sufficient time to address a false alarm. Once these three minutes have elapsed, the power is isolated and a signalling device is activated. This device demonstrates to the fire services arriving at the dwelling that the power is off, therefore permitting the use of water to tackle the fire.

If this cannot be guaranteed, fire services must spend additional time having a longer safety briefing focused on electrocution risks, as well as attempting to find the fuse box to manually isolate the power.

The use of our product will reduce response time of the fire services, thus reducing fatalities and financial costs of fire damage.

Team: Leonidas Aristodemou, Jessica Manning, James Popper, Kamran Tajbakhsh

Rota-Pill

There is a serious problem in the UK with ensuring the correct administration of medication. The National Institute for Clinical Excellence (NICE) estimates that of the £9 billion worth of medication dispensed by the NHS each year, more than £100 million worth is returned unused to be destroyed. Rota-Pill can help address this issue by assisting those who are starting to encounter physical and/or cognitive difficulties in the daily administration of their medication. The Rota-Pill dispenses medication directly from personalised blister packs filled for patients at the pharmacist. The user must simply turn the dial to the current time and pills intended to be taken at that time will be dispensed into a cup for easy consumption.

Team: Jack Beattie, Tim Palmer, Ciara Wheeler

Snowriski

Taking advantage of a gap in the ski lock market, Snowriski has designed an innovative locking mechanism for a pair of skis. This new design is built within the skis themselves, relieving the skier of carrying the lock around or forgetting to take it along in the first place. With ski theft becoming an increasing problem in ski resorts across the world, this lock is more than a deterrent. Its robust and compact design locks the brakes on one ski to the other around a uniquely compatible Snowriski rack. In addition to these features, this lock is designed to be water- and ice-proof, unlike those on the market today.

Team: Renate McKenzie-Onah, Thomas Nesch, Guy Peters, Anahita Pradhan

True Blue Markets

Cambridge is one of the few towns in Britain with a permanent outdoor market, providing a bustling focus during opening hours. Cambridge Market Square should be the centrepiece of the town. However, the current stalls are ugly permanent structures, made from metal scaffolding. When the market has closed the square looks desolate. True Blue Markets has designed a stall which is aesthetically pleasing, made using locally sourced material and labour, allows the square to be used outside of market hours and is deployable in less than 15 minutes. When the market closes it collapses into a bench, providing storage space for stallholders, seating for the public and turning the square into mostly open space. The benches can also be fork-lifted away to free the square completely.

Team: Thomas Cole, Shakti Kumpavat, Stephanie MacAulay, Nicholas Schulman

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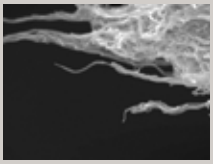

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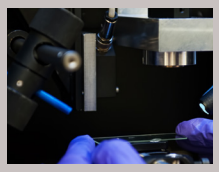

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www.ifm.eng.cam.ac.uk/services/large

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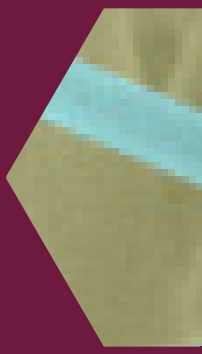

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