

Institute for Manufacturing

People Projects and Activities

2013

FOREWORD



It has been another exciting year for the IfM with rapidly growing interest in manufacturing and industrial strategies, both in the UK and around the world. Our newer Centres in Service, Industrial Sustainability and Policy are making excellent progress whilst our core Engineering and Management Centres continue to flourish.

Our attention is now focused on future directions for manufacturing and IfM colleagues have been involved nationally and internationally in Futures and Foresight Projects. This is helping to guide our own plans for the future. Three themes stand out as presenting the greatest challenges to manufacturing and industrial systems more broadly - emergence, growth and sustainability.

Emergence is concerned with ensuring that new ideas and opportunities are exploited as efficiently and rapidly as possible. Growth is concerned with making the best use of our productive capabilities. Sustainability is concerned with ensuring that future industrial systems are sustainable, both environmentally and economically.

All these challenges require an integrated understanding and application of engineering, management and policy for which the IfM is very well equipped. We look forward to welcoming new friends and collaborators from industry and the public sector over the coming year and playing our part in the renaissance of manufacturing.

A handwritten signature in black ink, which appears to read 'Mike Gregory'. The signature is fluid and cursive.

Professor Sir Mike Gregory
Head, Institute for Manufacturing

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HIGHLIGHTS



2012 was another outstanding year for the IfM throughout its key activities of research, education and practice. A new research programme has been launched and we actively participated in major new projects, including collaborations with colleagues from the Engineering Department and other parts of the University. Our mainstream undergraduate and postgraduate education programmes remain heavily oversubscribed and our events for industry attract large numbers of delegates and high profile external speakers. In response to the growing demand for tailored courses for major global corporations we have been developing a new education programme for the manufacturing leaders of the future.

Education

Our MPhil in **Industrial Systems Manufacture and Management** (ISMM) has seen the number of applications rise steadily in recent years and we now have more than five applicants for every place. Similarly, the IfM's core undergraduate programme, the **Manufacturing Engineering Tripos** (MET) also goes from strength to strength attracting high calibre candidates in increasing numbers. In conjunction with Cranfield University, IfM is running the new EPSRC-funded Doctoral Training Centre in Ultra Precision offering an **MRes/PhD** programme which will train a new generation of leaders in ultra precision engineering. Meanwhile, researchers from the Centre for International Manufacturing have been teaching the first tranche of students from the Doctoral Training Centre in Continuous Manufacturing and Crystallisation.

We are delighted that many of our cohort of over 80 PhD students are experienced professionals from a wide range of industries. They bring a wealth of expertise to the IfM and their backgrounds ensure that their work is focused on real industrial needs.

Research

Our new **Centre for Science, Technology & Innovation Policy**, funded by the Gatsby Charitable Foundation, is looking at why some countries are better than others at turning new technologies into emerging industries. Their findings will be used by policymakers and government agencies who are actively supporting the research communities in their efforts to create economic wealth from innovation. A related initiative, the **Babbage Industrial Policy Network** is designed to extend the community of people, particularly engineers and economists, who have an interest in manufacturing systems and industrial policy.

The **Centre for Technology Management** has launched a new academic-industry partnership, the **Strategic Technology & Innovation Management Consortium** to co-develop and apply industrially-focused research projects. Meanwhile, the **Cambridge Service Alliance** grows apace with the arrival of a new partner, Pearson, which is developing the service it offers to universities, particularly in North America.

The IfM is also playing an integral part in exciting new research collaborations. The **Distributed Information and Automation Laboratory** has been an active participant in the University's new **Centre for Smart Infrastructure and Construction** and the **Inkjet Research Centre** is a key partner in the KACST-Cambridge Research Centre, a collaboration between the King Abdulaziz City for Science and Technology (KACST), Riyadh and the University of Cambridge. Tim Minshall, head of the **Technology Enterprise Group**, supported by many of his IfM colleagues, is leading the Engineering Department's strategic theme on inspiring research through industrial collaboration.

Education and consultancy services

IfM ECS has been very active in the public sector following on from its publication in February 2012 of a major study, ***A landscape for the future of high value manufacturing in the UK***, commissioned by the Technology Strategy Board (TSB). The report linked current and emerging capabilities and technologies with promising future industrial opportunities leading to the identification of critical competences for the UK in the future. The study has been supplemented by 'deep-dive' studies initially in the Health and BioSciences sector. We have also been supporting the TSB to roadmap other emerging technologies such as synthetic biology, algal bioenergy and robotics and autonomous systems.

2012 saw the launch of a new programme, **Practical & Innovative Solutions for Manufacturing Sustainability** (PrISMS), for start-ups and small and medium-sized manufacturers in the East of England who want to grow their business while reducing their costs and overall carbon footprint. IfM ECS also manages **ideaSpace**, part of the University of Cambridge's Hauser Forum, and a hub for early stage innovation. ideaSpace continues to thrive with 75 companies using its co-working facilities and it has plans in place to expand into a central Cambridge location in 2013.

Public engagement

Hundreds of families flocked to the IfM's **Science Festival** event in March 2012. Visitors were treated to talks, demos and hands-on activities including laser rocket racing, talking robots and 3D product printing! We are looking forward to opening our doors again for the 2013 event on 23 March.

As well as the Science Festival, we were pleased to host a number of visits by school children – helping to showcase modern manufacturing to the next generation's potential engineers, scientists and technologists. Tim Minshall has also been busy challenging schoolchildren's perceptions of engineers. His TedX talk (available on YouTube) has had an extremely positive reaction and prompted, among other things, a request from the BBC for help explaining tricky engineering concepts to five and six year-olds.





Design Management Group (DMG)

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It is widely recognised that the design of great products and services is a key factor in the success of firms. The way in which the product development process is managed is critical to this success. The Design Management Group is interested in how design can be effectively managed to create sustainable, desirable, usable and producible new products and services. Central to this aim is the role of design as an integrator between technology and users. We are also active in understanding and promoting the importance of design at a national level.

PEOPLE

Director: James Moultrie

Current researchers: Wei Liu, Bernard Dusch, Jonathan Johnson, Krista Keranen, Karen Miller, Jae-Hwan Park, Carlos Peralta-Mahecha

Past researchers: Laura Sutcliffe, Nani Brunini, Alex Driver, Burcu Felekoglu, Andrew Muir Wood, John Stevens



SELECTED PROJECTS

A simple approach to design for manufacture

There are a range of methods for helping designers evaluate the producibility of new products.

We have developed a simplified form of these systematic approaches for use exclusively in a workshop setting.

User involvement in New Product Development (NPD)

A new PhD project is exploring the ways in which firms involve users in new product development. Specifically, this will explore whether traditional methods (such as interviews, focus groups) are being eclipsed by newer approaches facilitated by the internet.

Top management involvement in NPD

NPD has long been considered a high priority strategic issue to sustain competitive advantage and growth. The involvement of top managers in NPD is seen as a critical factor affecting performance. This project investigates top management involvement in NPD at project level from the perspective of both top management and the development team.

Managing feasibility in the medical device industry

Biotechnology and healthcare developments require huge investment and a complex multidisciplinary structure which is inherently full of risks and uncertainty. In this context early technology assessment and proof of principle is often sporadic and unstructured. Existing design process models for the medical healthcare industry are predominantly suited to the later phases of

development. This research provides a theoretical framework which offers practical guidance in improving development efficiency within the front-end phases of healthcare development.

Design in science

Little research has been carried out looking at the role of design in the early stages of technology development. The Design in Science study aimed to address this gap, by involving designers in live scientific research projects at the University of Cambridge. The research has demonstrated that early involvement by process designers can challenge the research direction and support scientists in demonstrating, communicating and exploring potential future applications. The project team worked with scientists to develop a design concept for a table incorporating moss which could be used to produce energy by photosynthesis to power a lamp. A book, *Design in Science: Exploring how industrial designers can contribute to scientific research*, is available at www.ifm.eng.cam.ac.uk/research/dmg/resources/

A toolkit for sustainable design

This project has developed a unique tool to enable designers and engineers to better understand the complexities of sustainable design. The toolkit includes a set of over 100 cards which individually contain specific design strategies. Each strategy is targeted at a specific stage of the product lifecycle. The tool is used in a workshop setting and helps to structure creative brainstorming with a view to improving the sustainability of products.

Co-design of services

From co-production to co-creation (CoCo): In this research, co-creation means collaboration in the creation of value through shared inventiveness, design, and other activities. Co-production is more narrowly defined as participation in service production within parameters defined by the

focal organisation. This research project aims to identify co-production/co-creation activities and roles in business to business service relationships and to develop models and management tools for effective and efficient co-creation of services.

Design management in the retail industry

This project is investigating why there is a tension between the role and contribution of design management in large retailers in the UK, US and EU. It focuses on design management of own-brand general merchandise products, where there are intensive design requirements and seeks to understand the barriers that exist within retail organisations.

ACTIVITIES

Cambridge Academic Design Management Conference

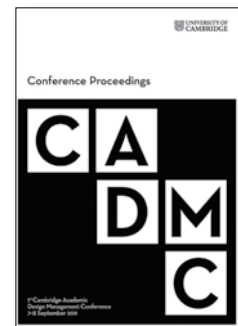
In 2011 the Design Management Group hosted the first Cambridge Academic Design Management Conference. This international conference is supported by *Creativity and Innovation Management Journal*. A second conference will be held in September 2013 on Design management: past, present and future.

Tools for managing new product development

In partnership with IfM Education and Consultancy Services, this work seeks to develop simple visual tools for the improvement of product development management, especially in small firms.

FUTURE WORK

The 'Design in Science' work has begun to provide some real benefits to scientists, and it is our intention to extend this work further. Work will also continue in all of the key themes outlined above, with an emphasis on strategic design, sustainable design, design trends and NPD management.





Distributed Information and Automation Laboratory (DIAL)

www.ifm.eng.cam.ac.uk/dial

dial-enquiries@eng.cam.ac.uk

DIAL studies ways in which advanced information and automation systems and automated identification technologies, such as radio-frequency identification (RFID) and software agents, can be used to create smart products, flexible, reconfigurable industrial operations and innovative services. DIAL incorporates the Cambridge Auto-ID Lab, which was a founding partner in the Auto-ID Centre project to bring affordable RFID to the consumer-packaged goods industry. DIAL is also a key partner in the Cambridge Centre for Smart Infrastructure and Construction (CSIC) and the Cambridge Service Alliance. DIAL's interests cover all aspects of automation and information management across the industrial supply chain.

PEOPLE

Director, DIAL: Duncan McFarlane

Deputy Director, DIAL: Ajith Parlikad **Director Cambridge Auto-ID Lab:** Mark Harrison

Associate Director Auto-ID Lab: Alan Thorne

Researchers: Alexander Borek, Rachel Cuthbert, Vaggelis Giannikas, Torben Jess, Zhenglin Liang, Wenrong Lu, Nipat Rasmekomen, Joao Fonseca de Silva, Pankaj Sood, Raj Srinivasan, Maurizio Tomasella, Philip Woodall

Support: Petra Kasmanova, Simon Sennitt



SELECTED PROJECTS

Information quality for asset management: a three-year Research Council-funded project seeking to determine the impact of improving information quality on managing assets throughout their life cycle.

Whole-life management of infrastructure assets: aims to develop tools and methodologies to support through-life decision-making and information management for infrastructure assets such as rail networks, buildings, water and sewage networks.

Futureproofing of industrial infrastructure: addresses the challenges in storing and managing data related to infrastructure assets throughout very long lifetimes of the assets. Industrial partners include: Arup, IBM, Laing O'Rourke, Redbite, London Underground, Scottish Water, The Woodhouse Partnership and Cementation Skanska.

GS1/EPCglobal: DIAL has actively contributed to the development of a set of global standards associated with RFID. Current work is supporting technical standards development at GS1/EPCglobal on discovery services and a network-centric

approach to electronic pedigree. These are both concerned with serial-level traceability/visibility of uniquely identified objects as they move through supply chains.

Maintenance of complex engineering systems feasibility study: a six-month scoping activity with Cranfield University working on improving knowledge of the behaviour of the production system and its maintenance.

Achieving Leveraged Advantage from Distributed Information (ALADDIN): this project, sponsored by Boeing, is examining novel ways to support automated exchange of critical data between organisations. The main notion is that data can be enabled so as to determine where and to whom it should be sent.

Disruption Tolerant Automated Lean Factories (DisTAL): a three-year project funded by Boeing, focuses on improving the resilience of manufacturing automation in the face of operational disruptions.

Hitachi Rail – fault diagnosis and maintenance engineering: a project aiming to develop an intelligent, adaptive, self-learning fault data management approach and fault-diagnosis tool for train systems.

Industrial uses of ‘internet of things’: DIAL was one of the early initiators of the ‘internet of things’ concept. Current work is examining its role in manufacturing.

Value of information: a series of PhD projects has evaluated the value and numerical benefit of improved information in a range of areas from supply chain to recycling and maintenance. Current efforts focus on services and infrastructure.

Airport performance: a sequence of projects involving the main UK airport operators have examined the role and value of better IT systems and new technologies such as RFID in airports.

Recent work has focused on the most efficient use of runaways and on streamlining the aircraft turnaround operations.

ACTIVITIES

Centre for Smart Infrastructure and Construction (CSIC): DIAL is involved in the new CSIC centre which brings together leading research groups across the University of Cambridge. (See page 29.)

Defence industry forum: working with a defence industry forum on the use and adoption of automated ID technologies. Partners include: MoD, BAE Systems, Rolls-Royce, Agusta Westland.

Auto-ID Labs: a global network of universities working on common challenges related to RFID, sensor networks and the ‘internet of things’.

FUTURE PLANS

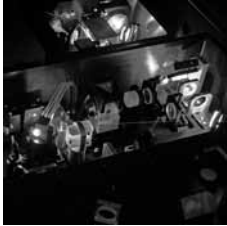
Energy and information: new approaches to reducing energy consumption and greenhouse gas emissions through better use of information and automation in industrial environments, including logistics and transportation.

Tools for industrial reconfigurability: system reconfigurability is a key way of future-proofing industrial systems against changes to their operating environment. This work considers reconfigurability challenges in manufacturing, construction and airport environments.

Auditing industrial resilience: development of methods to allow industrial companies to assess their ability firstly to record and, secondly, respond to disruptions in the operating environments.

Value of sensing in infrastructure: exploring methods for determining the value of new sensing systems being used in key infrastructure development to assist in construction maintenance and facilities management.





Centre for Industrial Photonics (CIP)

www.ifm.eng.cam.ac.uk/cip
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CIP studies the application of industrial laser technologies in manufacturing enterprises. It aims to enhance laser-based manufacturing capabilities in a wide range of industrial sectors through research, development and application of advanced, high-power lasers and system technologies. The Centre is multidisciplinary and supports industry through R&D, technology transfer activities and training.

PEOPLE

Director: Bill O'Neill

Researchers: Andrew Cockburn, Martin Sparkes

Research students: Sina Habibi, Krste Pangovski, Caroline Earl, David Hopkinson, Karen Yu, Matthew Bannister, Wenhe Feng

CDT Students: Jiho Han, Raham Jahromi, Francisco Orozco, Jon Parkins

Visitors: Ian Bucklow, Markus Gross, Ralf Niemann, Ali Gokan Demir

Support: Sophie Gough **Technician:** Mike Herring



SELECTED PROJECTS

Laser assisted cold spray

Laser assisted cold spray is a Cambridge developed production process that enables novel combinations of materials and metals to be deposited on a substrate for the production of 3D components. The technique involves accelerating micron-sized powders to velocities of around Mach 2.0, and impacting them onto a laser illuminated surface. The whole process occurs in the solid state which means that micro structural properties can be controlled, with localised deposition, and metals with differing melting points combined. The process is capable of depositing several kg per hour. Current applications include the deposition of Ti based bio-medical coatings, hard facing materials such as WC, and thin layers of stainless steel on low C-Mn steel substrates for low cost anticorrosion solutions. The research project has

been supported through investments from the EPSRC through the Cranfield/Cambridge Integrated Knowledge Centre on Precision Engineering. The process is in its final stages of commercial development, and is being taken to market by a new University spin-out company, Laser Fusion Technologies Ltd.

3-D micromanufacturing

Current micro-engineering manufacturing methods developed over the last 50 years for Si semiconductors lack sophistication for today's applications. Contact lithographic methods and new nano-particle pastes are being employed to create a low cost, high performance fabrication route for micro-electronics fabrication. Applications include the manufacture of micro-CMM probes, micro-fluidic plates, simple transistor elements and printed ZnO light emitting diodes. The current work will see application developments in the

production of new nanomagnetic materials (Nd-Fe-B) for the creation of high performance magnets with a lower consumption of rare earth elements such as Nd, or Sm. As part of the international FP7 Hi-Wi project, the group is investigating novel manufacturing processes for rare earth permanent magnetic materials that will facilitate the production of new classes of magnets with enhanced magnetic properties, reduced rare earth consumption or better mechanical properties.

High power fibre lasers: SMART Laser

Manufacturing lasers are a source of £6Bn of global revenue for industry. However, they are an enabling technology for over some £1Tr of manufacturing business globally. CIP has established extensive fibre laser laboratories offering a number of processing capabilities and has a close working relationship with leading UK manufacturers of fibre lasers (SPI Lasers). Academic collaborators include: the Optoelectronics Research Centre, University of Southampton. A £1.3m TSB project is currently developing the next generation of low-cost high-performance picosecond laser technology, in addition to the realisation of in-process digital holographic process diagnostic tools. Laser manufacturing is dominated by several laser sources at traditional lasing wavelengths and long-pulse interactions. Industrial processes have been optimised using these available laser sources, but relatively little work has been undertaken to optimise the laser parameters to the process. In this project we aim to break beyond the bounds of current laser technology and investigate the performance of novel laser sources developed by a well-established consortium of academics and industrial partners.

EPSRC Centre for Ultra Precision

A new EPSRC Centre for Ultra Precision was launched in October 2012. The joint Cambridge

and Cranfield research centre is funded by the EPSRC and industry for five years in the first instance, and will lay the foundations of new ultra precision manufacturing capabilities for a wide range of industry sectors.

MRes postgraduate course

The joint Cambridge-Cranfield EPSRC Centre in Ultra Precision has developed an integrated PhD and EngD training programme in order to develop the precision engineers of tomorrow. Future industries will require a range of precision in their product manufacturing that stretches the capabilities of even the best manufacturing process technologies. The course will fund around 50 PhD students over the next five years to support the rapid industrial growth of precision-engineered products.

FUTURE PLANS

High brightness laser technology

CIP will further develop the research topic of ultra precision technologies including new Ne+ beam machining systems, holographic in process metrology, glass MEMS manufacturing and a host of other micro and nano technologies. Further work in conjunction with Aberdeen University, involves the development of underwater laser-cutting techniques for offshore oil and gas decommissioning.



Inkjet Research Centre (IRC)

www.ifm.eng.cam.ac.uk/irc/
irc-enquiries@eng.cam.ac.uk

The IRC was established in March 2005, strongly supported by a group of UK companies, to carry out research into the generic science which underlies this important technology. The IRC houses experts in inkjet technology, fluid mechanics, visualisation, analysis and computation to study jet and drop creation, drop flight and drop/surface interaction.

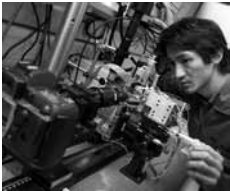
PEOPLE

Head of Centre: Ian Hutchings

Director of Inkjet Research Centre: Graham Martin

Researchers: Alfonso Castrejon-Pita, Rafa Castrejon-Pita, Ronan Daly, Steve Hoath, Wen-Kai Hsiao

Support: Alice Cozens



PROJECTS

Inkjet technology for 3-D printing

This project investigates the use of inkjet technology for the fabrication of 3-D components, in particular via printing on to powder beds.

Innovation in industrial inkjet technology: I4T

A consortium, led by the University of Cambridge, has been awarded a multi-million pound EPSRC grant to investigate how inkjet print technology could revolutionise manufacturing processes.

The consortium comprises collaborators from two other Cambridge departments, the Universities of Durham and Leeds, and a group of eight companies which include the major UK players in the inkjet sector.

The award, with additional funding from industry, supports a five-year programme of research to study the formulation, jetting and deposition of specialist printing fluids, and develop an overall process model. This work will improve

the robustness of industrial inkjet printing and help companies develop new applications for the technology such as flat-panel displays, printed electronics, and photovoltaic cells for power generation.

Biognostix

The Biognostix project addresses the growing need for affordable, point-of-care testing to detect, diagnose and monitor diseases and infections through developing technologies and flexible manufacturing methods for the customisable fabrication of inexpensive diagnostic multiplex test sensors on fibre-based substrates.

As a partner in this EU FP7 project, we are developing a manufacturing route involving inkjet printing for paper-based, low cost medical diagnostic devices.

Diginova

This EU FP7 project has created a consortium to analyse the future prospects for digital fabrication, in particular by inkjet printing.



The KACST-Cambridge Research Centre

The IRC is a key partner in the new KACST-Cambridge Research Centre, a collaboration between the King Abdulaziz City for Science and Technology (KACST), Riyadh and the University of Cambridge. The Centre will form the platform for cooperation in scientific research, the transfer of technology and the training of postgraduate students and post-docs within the two institutions.

The centre, funded by KACST, focuses on inkjet and three other areas of research and emerging technologies of particular importance to Saudi's long-term development strategy.

ACTIVITIES

Inkjet Interest Group

The IRC has established an Inkjet Interest Group as part of the EPSRC and industry-funded project investigating fundamental aspects of inkjet. This group meets regularly to hear talks on inkjet related subjects. As well as hearing presentations by invited speakers this is an opportunity to meet others in various industries with similar interests.

FUTURE PLANS

Inkjet technology

We have developed internationally-leading diagnostic techniques for studying both the formation and deposition of tiny fluid droplets, and are currently exploring new research opportunities which will build on this expertise. Applications include conventional graphics printing and direct-write manufacturing of functional components.

NEW BOOK

Inkjet technology for digital fabrication

Edited by Ian M. Hutchings and Graham D. Martin

A comprehensive overview of the use of inkjet printing for digital fabrication along with practical information on industrial applications, with contributions from academic researchers and leading names in industry. Opening chapters cover the essential theory and principles involved in inkjet printing, and later chapters address current practice and problems.





Centre for International Manufacturing (CIM)

www.ifm.eng.cam.ac.uk/cim
cim-enquiries@eng.cam.ac.uk

CIM focuses on applied research in close collaboration with industrial partners. The Centre has developed a strong academic-industrial community and provides expertise and a range of industrial services in the areas of international manufacturing and supply networks, particularly factory/plant management, operations network configuration and design and the development of system capabilities.



PEOPLE

Head of Centre: Jag Srari

Research Director: Yongjiang Shi **Staff Researchers:** Tomás Harrington, Mukesh Kumar, Leila Alinaghian

Research students: Jialun Hu, Xin Jin, Wenwen Zhao, Arsalan Ghani, Kurt Liu, Amy Shang, Rasha Rezk, Helen Zhang, Yang Liu, Feifan Chang, Alex Kouptsov, Huey Yuen Ng, Xingkun Liang, Ying Chen

Industrial practitioners: Paul Christodoulou, Don Fleet, Andrew Gill, Dennis Lewis

Administrator: Elizabeth Barrington-Light

SELECTED PROJECTS

Global supply networks

New forms of supply network are emerging to support novel business models and exploit emerging technologies. The research examines the influence of supply network configuration, network capabilities and the adoption of advanced supply chain processes. The identification and development of core competences in the supply chain to support faster growth is examined at a cross-sector level.

Production networks

The research focuses on a company's international 'manufacturing footprint' – the locations and roles of its plants around the world. Projects include the internationalisation process of multinational companies including reasons to pursue cross-border production; production network configuration, development and coordination; and risk and reward management in overseas investments.

Service in multi-organisational networks

Projects include service business development in manufacturing companies in terms of strategic context and capability development. The research involves work on service supply chain performance metrics, and network organisation design and configuration methodologies.

Global engineering networks

The research examines how companies manage their globally dispersed engineering operations in changing business environments. This activity also includes a number of industrial projects and benchmarking activities with non-competing organisations. A new international research collaboration seeks to share research in this area.

Mapping global value chains

This integrates research on firm networks, supply networks and global value chains. Projects study the dynamics of industry structures at international, national and regional levels. The work focuses on sector industrial landscape mapping

techniques, integrating research on industrial network risk and resilience. A key focus is on networks involving more 'open' manufacturing systems, building on work developed in mature sectors and more recently applied within new technology-based projects, as part of the Cambridge Integrated Knowledge Centre. We are also looking at disaggregated value chains, increasingly found in healthcare and food sectors, where regulation and new technology developments are resulting in more fragmented supply chains. This research is supported by the new **EPSRC Centre for Innovative Manufacturing in Continuous Manufacturing and Crystallisation**, which is looking at the supply chain implications of changes to more continuous manufacturing systems.

Effective post-M&A integration

CIM has developed an application process guide and tools for effective post-M&A integration, building both on the recent Research Council-funded programme and on emerging research into non-equity based partnerships.

Sustainable supply networks

Building on work with major multinational companies, this research seeks to develop methods and tools for enabling the design and configuration of sustainable industrial networks. It focuses on high value manufacturing sectors that consider long-term security of supply. The food security challenge is part of the University's Global Food Security initiative, with two new strands of activity, one looking at supply chains that support renewable chemical feedstocks, and the other considering the impact of climate change on the resilience of international supply networks.

Last Mile Logistics and developing e-commerce friendly supply chains

Two TSB funded projects on Last Mile Logistics are

aimed at reducing urban congestion through item consolidation and flexible, customer-choice driven, traceable supply. Research will continue on the application of Last Mile Logistics to urban contexts, with links to emerging work on new routes to market, specifically in relation to e-commerce friendly supply chains. Both research projects are sponsored by industry consortia involving OEMs, and internet and logistics providers.

Internationalisation

The research seeks to explore how emerging country MNCs are internationalising and how their evolution paths differ from developed world multinationals, contrasting models from more established firms and those beginning to develop their international manufacturing and sourcing footprints. Initiatives include the setting up of a Chinese Industry Studies Group (CISG) looking at Shanzhai manufacturing models and the emergence of the low-speed electric vehicle ecosystem. In India, as part of the UKIERI programme, working closely with Indian Institutes, the second year of a two-year research programme focuses on Optimising Food Supply Chains, particularly seed-to-shelf network integration.

ACTIVITIES

CIM Symposium

The 17th annual symposium in 2013 will focus on disruptive supply chains, and how firms are responding to changing supply-side networks involving increasingly partnered industry structures, the emergence of intermediate suppliers and contract manufacturers, and downstream innovation in terms of the growth in delivery systems including the development of e-commerce channels.



UK university collaborations

Bath
Birmingham
Brunel
Exeter
Leeds
Loughborough
Nottingham
Southampton
Strathclyde
Warwick

International

Copenhagen
Business School
Indian Institute of
Management
Karlsruhe
Munich
Sao Paulo
Tokyo
Trinity College Dublin
Tsinghua
University College
Dublin
Zhejiang



Centre for Strategy and Performance (CSP)

www.ifm.eng.cam.ac.uk/csp

csp-enquiries@eng.cam.ac.uk

CSP combines academic objectivity with industrial know-how to help companies tackle their strategy and performance management. It aims to understand and improve the way strategic choices are made, plans are developed and implemented, and performance is measured and achieved. CSP has an established track record of advancing academic theory through successful participation with industry to ensure industrial relevance.

PEOPLE

Director: Ken Platts

Researchers: Carmina Buzuloiu, Tanya Edwards, Philipp Egger, Gerry Frizelle, Friederike Hoffmann, Mohamed Khater, John Mills, Rich Morales, Hans-Georg Mundhenke, Mohammed Salloum, Tomasz Szejner, Claus Weidinger, Sascha Wischek, Yue Zhao

Industrial practitioners: Nicky Athanassopoulou, Derek Ford, John McManus, Dominic Oughton

SELECTED PROJECTS

Strategy modelling and visualisation

Developing visual approaches to support strategy development that help companies deal with the large amounts of complex information involved. In partnership with University of St Gallen, Switzerland.

Developing strategy for start-ups

Developing strategy in start-up companies when bringing a new technology, product or service to market.

Technological innovation in consumer goods firms

The strategic process of identifying and commercially exploiting technological innovation in large scale global firms in the Fast Moving Consumer Goods industry.

Innovation ecosystems

Investigating the attributes and enablers of

innovation ecosystems. This is a multiple country study, initially involving Finland, Germany and countries in the Middle East and North Africa.

Business strategy process

Developing a facilitated process that helps identify markets and competences, and create vision and action in small and medium manufacturers.

Capability and resource analysis

Studying the way companies co-ordinate resources to improve capabilities and performance.

Production system choices

Studying the impact that global manufacturing strategies have on the choice of production system. Initially, studying the variation in production systems used by global operating companies in the automotive supply chain.

Strategies in high-growth SMEs

Identifying the catalysts and hurdles in strategy formulation, definition and implementation in

high-growth SMEs and developing a framework of factors instrumental to the development of such firms.

Servitization

Developing tools to support 'availability contracting' – enhanced service contracts covering a product's entire life. We consider the cultural, organisational and risk factors involved in moving from manufacturing to service provision. A particular focus is the application in the defence industry.

Business excellence model for transitional economies

Modification of business excellence models to measure organisational performance in companies in countries changing from a centrally-planned to a free-market economy.

Performance measurement

Developing a tool for the evaluation of performance measurement systems.

The future of performance measurement

A multi-university study in conjunction with partners in Europe and the USA to identify key challenges in performance measurement over the next five to ten years, with a view to setting a forward research agenda.

ACTIVITIES

Centre Associates Programme

This programme is establishing more formal and closer working relationships with a number of alumni who are now reaching senior positions in organisations, in order to provide a mechanism for improved dialogue and technology transfer.

Business strategy tool

Working in collaboration with IfM Education and Consultancy Services, the Centre offers a business

strategy tool based on a series of four facilitated workshops that help companies to:

- analyse their operational environment
- assess their capabilities
- develop a clear strategy
- implement action plans

Executive education

The Centre offers executive education programmes on strategy and performance.

Short courses

The Centre offers occasional one-day courses on topics related to strategy and performance.





Technology Enterprise Group (TEG)

www.ifm.eng.cam.ac.uk/teg

thwm100@eng.cam.ac.uk

The Technology Enterprise Group (TEG) is a network of researchers and associates focused on research and education relating to the origins, start-up and growth of technology-based ventures and their impact upon the economy.

PEOPLE

Head of Group: Tim Minshall

Researchers: Keith Cotterill, Nicola Dee, Lee Liang Ge, Sarah Lubik, Letizia Mortara, Luzselene Rincon, David Weiss, Joonmo Ahn, Bettina Blasini.

Visitors: YiWen Yang, Robert Baron, Dominik Deradjat, Patrik Schmithausen.



SELECTED PROJECTS

TEG research is focused around three themes: open innovation, investment and university-industry knowledge exchange.

Open innovation

Current TEG research projects in this area are: investigating the role of intermediary organisations in helping firms implement open innovation, the influence of location on open innovation strategies for SMEs in the UK and South Korea, strategies for collaboration in emerging sectors, and the role of communication within an open innovation ecosystem. The outputs of completed TEG research on open innovation have been converted into teaching and training materials to support firms in implementing open innovation.

TEG open innovation activities can be connected to via twitter at twitter.com/camoinet and at <http://openinnovationblog.blogspot.co.uk>

Investment and incubation

TEG research on investment is currently focused on how entrepreneurs learn from prior failure when setting up new ventures, the linkages between

business incubation and the need for start-ups to raise investment, and the availability of investment for new firms in emerging industries.

University-industry knowledge exchange

Current work is focused on a range of issues relating to the establishment, operation and impact of long-term partnerships between engineering firms and universities. This work has strong links to projects on open innovation and location, and to the Engineering Department's strategic theme on 'Inspiring Research Through Industrial Collaborations'. More information can be found at www.engineerimpact.info

ACTIVITIES

TEG members are involved in coordinating a range of activities that support the core research projects.

Open Innovation Research Forum

TEG coordinates the Open Innovation Research Forum (OIRF), an international network of researchers focused on identifying, understanding and addressing the challenges of implementing open innovation. The work of OIRF has been

supported by the UK Innovation Research Centre (UKIRC) and the Institute for Technology, Enterprise and Competitiveness (ITEC) at Doshisha University in Japan. For more information, go to: www.oirf.net

Cambridge Technopole

TEG has run several projects examining aspects of the growth of the Cambridge high tech business cluster, and manages a website and blog providing access to resources to help support informed debate about its past, present and future developments. For more information see cambridgetechnopole.blogspot.com or follow twitter.com/camtechpole

University enterprise activities

TEG supports University-based enterprise programmes including: the University Enterprise Network, Cambridge University Entrepreneurs, and the i-Teams programme. Information on these activities is brought together at: www.enterprisenetwork.group.cam.ac.uk

'Inspiring Research through Industrial Collaboration'

TEG coordinates Cambridge University Engineering Department's strategic theme on 'Inspiring Research through Industrial Collaboration'. This theme has three areas of activity to support the formation and management of collaborations between academics and industrial partners:

1. **Investigate** - developing and sharing a library of good practices in the setup and management of partnerships
2. **Inspire and Inform** - providing online resources and running events to highlight the opportunities and explain the practicalities of partnerships
3. **Implement** - supporting academics and potential partners in the development of collaborative activities.

Further information can be found at: www.engineerimpact.info

FUTURE WORK

In the coming twelve months new research projects will be examining the role that new models of investment when coupled with new production technologies can play in changing approaches to innovation and entrepreneurship.





Centre for Technology Management (CTM)

www.ifm.eng.cam.ac.uk/ctm

ctm-enquiries@eng.cam.ac.uk

CTM focuses on helping companies make the most appropriate use of current and future technological resources. It aims to provide comprehensive support to managers, based on an integrated understanding of science, engineering and business.

PEOPLE

Director: David Probert

Academic staff: Elizabeth Garnsey (Emeritus), Tim Minshall

Researchers: Clare Farrukh, Simon Ford, Clive Kerr, Rick Mitchell, Letizia Mortara, Robert Phaal, Michèle Routley, Judith Shawcross

Research students: Joonmo Ahn, Bettina Blasini, Clemens Chaskel, Laurens Chaskel, Keith Cotterill, Lee Liang Ge, Daniel He, Julia Fan Li, Imohiosen Ilevbare, Jan-Niklas Keltsch, Ahmed Mashhour, Elliott More, Victor Ortiz, Harald Overholm, Luzselene Rincon, Val Thorn, Manjusha Thorpe, Chung-Lin Tsai, Carol Walton, David Weiss, Man Hang Yip

Affiliates: Marcel Dissel, Eoin O'Sullivan, Sarah Lubik

Visitors: Robert Baron, Dominik Deradajat, Neil Gregory, Changyong Lee, Leonardo Augusto Gomes, Shuichi Ishida, Ruth Thomson, Yi-Wen Yang

Industrial practitioners: Nicky Athanassopoulou, Bill Colquhoun, Andrew Gill, Steve Mann, Dominic Oughton, Derek Ford.

Support: Geraldine Guceri

SELECTED PROJECTS

Strategic technology management

Mapping industrial emergence: based on a diverse set of historical case studies, this provides a foundation for developing improved strategic management tools for navigating current and future emergence. A set of four related tools has been produced.

Visualisation for strategy and innovation: to develop improved understanding and practice for supporting strategic dialogue and communication, applied to roadmapping and other technology management frameworks and tools.

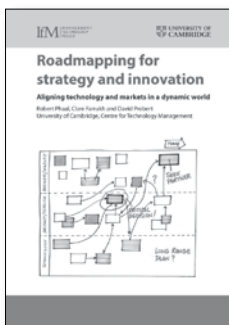
Strategic technology management toolkits:

how methods such as roadmapping, portfolio management and scenario planning can be brought together in a systematic and practical way.

Doctoral research: the role of the chief technology officer, treatment of risk and uncertainty in strategy, the alignment of technology and corporate strategy, how sustainability drivers influence corporate strategy, industry platform strategy in the ICT sector, the IP value of software development, and resilience in public safety networks.

Innovation management

Open Innovation Forum: facilitating a structured programme where members share best practice,



explore 'hot topics' along the FMCG value stream and participate in optional, accelerated open innovation collaborations.

Technology acquisition and protection: the benefits and challenges of collaborative early-stage technology development, in terms of sharing costs and risks while managing the intellectual property implications.

Project selection and portfolio management: improved methods for selecting innovation projects and managing the portfolio of technology investments, including weighted scoring methods and options analysis.

Doctoral research: partner selection in collaborative technology developments, managing ideas at the fuzzy front end of innovation, scale-up in the chemical process industry, impact of consulting on the technology-marketing relationship, product-service system design in healthcare, and technology protection in technology ventures.

Technology enterprise

The Technology Enterprise Group is part of the Centre for Technology Management. It focuses on three key research themes:

- Open Innovation
- University-industry knowledge exchange
- Technology business investment and incubation

(See pages 12 and 13 for more details.)

ACTIVITIES

Education and events

CTM has a growing portfolio of workshops, short courses, teaching modules and executive education linked to its research findings in technology and innovation management. Key courses cover strategic roadmapping, technology

and innovation management, valuing and selecting technology projects, technology intelligence, visual design for strategy and innovation, and early stage technology management. Courses can either be open or tailored to the needs of the sponsoring organisation.

European Institute for Technology and Innovation Management (EITIM)

EITIM is a collaboration of ten leading technology-based universities across Europe that aims to improve wealth creation from science and technology. It also supports an active research student community, EITIMdoc, with conferences and workshops on research practice.

www.eitim.org

FUTURE PLANS

A new industrial consortium launched in 2013 will focus on networking and collaborative research in the field of strategic technology and innovation management. The Strategic Technology & Innovation Management (STIM) Consortium is a practice-oriented research and networking collaboration between industrial member companies and CTM.

International collaborations continue to develop with academic groups in the UK, Europe and around the world – notably Japan, China, Korea and Brazil.

New research will address emerging issues relating to the management of technology and innovation under conditions of increasing uncertainty (social, technical, environmental, economic and political).





Interdisciplinary and collaborative initiatives

www.ifm.eng.cam.ac.uk/research

ifm-enquiries@eng.cam.ac.uk

The IfM's interdisciplinary research programmes are focused on particular industrial challenges and typically draw on the breadth of disciplinary expertise from engineering through management to economics and policy



CENTRE FOR SCIENCE, TECHNOLOGY & INNOVATION POLICY (CSTI)

www.ifm.eng.cam.ac.uk/research/csti/

PEOPLE

Centre Director: Eoin O'Sullivan

eo252@cam.ac.uk

Researchers: Antonio Andreoni, Tomas Coates Ulrichsen, Laure Dodin, Carlos Lopez Gomez, Jae-Yun (Jane) Ho

CSTI is an applied policy research unit exploring what makes national innovation systems effective at translating new science and engineering ideas into novel technologies and emerging industries. Research projects are designed to support the evidence needs of Science, Technology & Innovation policymakers, in particular those officials in public research agencies who are responsible for programme design, portfolio management and strategy development. The CSTI research agenda is shaped in collaboration with policy and research agency partners.

CSTI's applied research activities are distinguished, in particular, by efforts to more carefully characterise the technologies, application systems and industrial structures involved in the journey from research to economic wealth; and by efforts to ensure that research outputs are directly relevant to the evidence needs of those government

agencies supporting the research and innovation base.

Research Themes

CSTI's research projects are organised within five closely integrated research themes:

THE PUBLIC RESEARCH BASE & THE DYNAMICS OF INNOVATION

Exploring the evolving contribution of public research and higher education organisations to technological and industrial change, and economic development.

TECHNOLOGICAL, MANUFACTURING & INDUSTRIAL SYSTEMS

Characterising enabling technologies, production technologies and processes, value chain systems (and associated industrial/innovation capabilities and competences) to better understand the dynamics of S&T-based industrial change.

SCIENCE, TECHNOLOGY & INDUSTRIAL EMERGENCE

Developing innovation system functions-based approaches to analysing emerging technology dynamics; and practical foresight-related analyses for policy and public research strategy development.

INNOVATION SYSTEM INSTITUTIONS: REGULATION & STANDARDS

Exploring the role of evolving innovation system 'institutions' (in particular standardisation and

regulatory activities) on the emergence of new technologies and industries.

ECONOMIC VALUE CAPTURE FROM INDUSTRIAL-INNOVATION SYSTEMS

Analysing sources of national economic value capture from modern manufacturing systems, in particular within the context of periods of technological and industrial change.

BABBAGE INDUSTRIAL POLICY NETWORK

www.ifm.eng.cam.ac.uk/research/brg/

PEOPLE

Antonio Andreoni, Ha-Joon Chang, Mike Gregory, Carlos López-Gómez, Eoin O'Sullivan

Inspired by Charles Babbage's legacy, the Babbage Industrial Policy Network gathers leading scholars as well as young researchers from economics, engineering and operations management with an interest in manufacturing and industrial policy. The Network acts as a reference point for researchers while creating a bridge with policymakers, international organisations and manufacturing firms.

The way in which countries at different stages of development can capture value through manufacturing is increasingly a concern for both policymakers and academics in a range of disciplines. Recent national manufacturing strategies recognise the need for an improved understanding of modern manufacturing systems for designing, implementing and evaluating industrial policies.

Modern manufacturing systems involve complex interdependencies, often across a range of industries, which contribute a variety of components, materials, production subsystems and production-related services. Rapid reconfigurations of production structures, technological and

sectoral inter-linkages, as well as geographical boundaries, characterise the global manufacturing landscape. No single discipline is fully equipped to disentangle such complexity and, as such, there is a need to consider different units of analysis and levels of aggregation at different points in time.

Approach

- Convene a community of researchers from economics, engineering and operation management with a shared interest in manufacturing systems and industrial policy.
- Develop a common language and identify complementarities across disciplines.
- Shape research agenda with policy makers.

Seminar Series

The Babbage Industrial Policy Network runs a series of seminars through the year. They reach a wide community of stakeholders with a shared interest in manufacturing systems and industrial policy from Cambridge and beyond. Details about upcoming seminars can be found at: www.ifm.eng.cam.ac.uk/research/brg/seminar/

Previous Babbage seminars

A NEW APPROACH TO INDUSTRIAL POLICY
Patrizio Bianchi, University of Ferrara and Emilia-Romagna Regional Government, Italy

INDUSTRIAL AND INNOVATION POLICIES IN BRAZIL: RECENT PATHS AND MAIN CHALLENGES
Mario Sergio Salerno, Polytechnic School, University of São Paulo, Brazil

CAPTURING VALUE IN MODERN MANUFACTURING SYSTEMS
Mike Gregory, Institute for Manufacturing, University of Cambridge, UK

INDUSTRIAL POLICY: CAN WE GO BEYOND AN UNPRODUCTIVE CONFRONTATION?
Ha-Joon Chang, Faculty of Economics, University of Cambridge, UK

Projects

RETHINKING INDUSTRIAL POLICIES: EMERGING APPROACHES IN OECD COUNTRIES

A comparative analysis of approaches to industrial policy, as articulated in national manufacturing strategies, across a selection of OECD countries.

“CHASING VALUE” IN MODERN NATIONAL MANUFACTURING SYSTEMS

A series of case studies in Singapore, US and Italy across different industries on how value in manufacturing may come from ‘unexpected places’.

SERVICE RESEARCH AND THE CAMBRIDGE SERVICE ALLIANCE

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

www.cambridgeservicealliance.org

PEOPLE

RAEng Professor of Complex Services

Andy Neely (Director of the Cambridge Service Alliance)

Professor of Industrial Information Engineering

Duncan McFarlane

Researchers: Ornella Benedettini, Alexander Borek, Rachel Cuthbert, Joao Fonseca da Silva, Tobias Graml, Jingchen Hou, Christopher Jackson, Nripen Kulkarni, John Mills, Rich Morales, Zied Ouertani, Ajith Parlikad, Chris Pearson, Nipat Rasmekomen, Giovanni Schiuma, Raj Srinivasan, Maurizio Tomasella, Taija Turunen, Ivanka Visnjic, Claire Weiller, Phil Woodall **Support:** Jacqueline Brown, Angela Walters

Service and support engineering is assuming an increasingly important role in the business models of technology-based and manufacturing companies as organisations shift from a product-based orientation to a more service-based focus. Services now represent over 75% of employment in the UK, and are increasingly important in

traditional product oriented industries such as aerospace, defence and transportation. The services provided (and used) in these industries are examples of complex service systems, where organisations must manage several areas of complexity simultaneously.

The IfM has worked with BAE Systems and IBM since 2005 to study manufacturers’ provision of through-life and other complex services - the ‘servitization’ of manufacturing. While service provision potentially offers more stable revenue streams and strengthens relationships between suppliers and customers, the transition to service provision involves significant additional business risk.

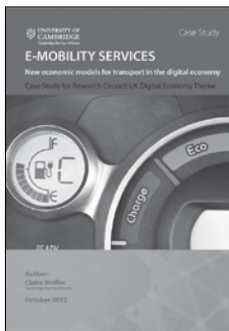
Cambridge Service Alliance

The Cambridge Service Alliance was set up in 2010 and now brings together the University of Cambridge, BAE Systems, Caterpillar, IBM and Pearson to find faster innovative solutions to the challenges of designing and delivering high-performance complex services. When they work well, complex services have the potential to be transformative, for organisations, industries and even regions. So the work of the Alliance is key to producing the insight and foresight needed, and to increase awareness of how mutually beneficial high-performance complex services will be designed and delivered in the future. The research carried out by the Alliance underpins its development of delivery of the tools, education and insights needed for complex services.

Alliance research focuses on three themes:

BUSINESS MODELS FOR COMPLEX SERVICE PROVIDERS

Previous Alliance research in business models for complex service providers has been around understanding the business model innovations of selected service providers, which resulted in



designing a business model framework. Building on this in 2012, the research has focused on developing an understanding of business model innovation for urban ecosystems, initially studying London, Vienna and Chicago.

Alongside this, research is underway into the capabilities that business-to-business service providers need if they are to move to service-driven business models. In addition, we have completed a case study research report into the identification of elements of successful business model innovation in electric vehicle ecosystems.

SERVICE AND SUPPORT ENGINEERING

As organisations are facing increasing pressure to deliver more for less, it has become of key importance that they develop effective asset management capabilities. Managing the assets required to deliver complex services is particularly challenging as they must deliver value across the supply chain and must be managed flexibly to respond to changing demands of customers and end-users.

In 2012 this theme focused on performance measurement and performance architectures for asset management. This research has resulted in the development of a performance architecture, which forms an essential part of understanding the linkages between performance measurement and stakeholder goals.

SERVICE PERFORMANCE AND INFORMATION

To date, current performance measurement frameworks have been inadequate for the highly partnered, collaborative networks required to deliver complex service solutions. In 2012 we have worked with our industrial partners to develop and test a method of specifying systems suitable for measuring the performance of complex, multi-organisation service networks. The design process is being developed and tested in conjunction with

five organisations to validate its robustness and enable industrial exploitation.

CAMBRIDGE SERVICE WEEK

A major event in the calendar of the Alliance is the annual Cambridge Service Week, held in September, and designed to push the boundaries of service knowledge. It hosts events for academics and practitioners as well as member organisations of the Alliance. In 2012, the industry one-day conference explored the potential for Big Data to transform the design and delivery of complex services in both the public and private sectors. The conference included keynote speakers from the Cabinet Office, Google, Vestas, BAE Systems Maritime Solutions, Caterpillar, Cambridge Service Alliance and IBM Software Group in thought-provoking presentations on the role of big data in service industries. Cambridge Service Week also hosted the EurOMA Service Operations Management Forum. The Forum brought together leading scholars from Operations Management and other disciplines to explore the Future of Services in a Connected World.



KT-BOX

The IfM led the KT-Box project, a consortium of six universities converting recent service research into practical tools and techniques that can be applied by providers and users of complex services. The project was funded by a £2.2 million EPSRC Knowledge Transfer Award, with additional contributions from BAE Systems, Bombardier, IBM, Rolls-Royce, the MoD and many smaller companies and not-for-profit organisations.

KT-Box has developed a toolbox which helps users improve their service offering:

- proposing new services (the value proposition)
- delivering services better (the value delivery)
- ensuring the services are valuable to the providers and users (value capture).



In 2012 we concentrated on helping users apply these tools to real situations, through secondments to industry and shorter engagements by researchers in firms.



CENTRE FOR INDUSTRIAL SUSTAINABILITY (CIS)

www.ifm.eng.cam.ac.uk/sustainability/

Director: Steve Evans

Programme coordinator: Claire Barlow

Researchers: Nancy Bocken, Mélanie Despeisse, Bernhard Dusch, Clare Farrukh, Lloyd Fernando, Simon Ford, Elizabeth Garnsey, Mike Gregory, Jialun Hu, Kyounglim Lee, Sotirios Levakos, Lampros Litos, ChenGuang Liu, Kurt Liu, Ioannis Mastoris, Maryam Masood, Elliott More, David Morgan, Sudhir Rama Murthy, Harald Overholm, Jae-Hwan Park, Ajith Parlikad, Rob Phaal, Jim Platts, Padmakshi Rana, Yongjiang Shi, Samuel Short, Jag Srai, Yuan Tao, Manjusha Thorpe, Miying Yang, Madeleine Yates, Helen Zhang.

This programme is developing technology and operational solutions to deliver products with reduced greenhouse gas emissions, reduced levels of consumption of non-renewable resources, reduced waste and improved social conditions.

These 'cross-centre' activities are embedded in a broad collection of research projects across the IfM, including activities in the Inkjet Research Centre, the Centre for Technology Management, the Centre for International Manufacturing, the Design Management Group, the Centre for Industrial Photonics, the Distributed Information and Automation Laboratory and the newly formed Centre for Industrial Sustainability.

The IfM is also the lead partner in a new EPSRC-funded Centre for Innovative Manufacturing, focusing on Industrial Sustainability, while IfM ECS



practitioners regularly engage with companies on issues associated with sustainability.

EPSRC CENTRE FOR INNOVATIVE MANUFACTURING IN INDUSTRIAL SUSTAINABILITY

This is a five-year project involving four universities (Cambridge, Imperial College, London and Cranfield and Loughborough Universities) and multiple companies and agencies. The aim is to develop knowledge, tools and techniques with industry and its stakeholders that help us move towards a sustainable industrial system.

Research project overview

Six 'Grand Challenge' projects have been developed

- Performance variation
- Resource efficient manufacturing
- Eco-intelligent factories
- Zero waste, zero emissions
- Sustainable value
- Configurations for sustainable industrial systems

Exploratory projects have been started in ten areas and completed in eight of these. They have helped to shape the Grand Challenges, produced tools and papers, set out new PhD projects and provide inputs for some of our key industry partners.

We have 19 PhDs underway with a further seven about to start. This is good progress towards our aim of 88 over the five-year period of funding.

Academic outputs

Across the four universities, our Senior Academics and Research Associates have been active in creating a wide range of outputs. They have had 28 papers published in journals or conference proceedings with a further nine under review. In addition, there have been lectures and

presentations at six major events and two public reports published. It is early in the research cycle to expect to see tool availability, but we have seen two in the area of Sustainable Value and a prototype in Sustainability Assessment.

Policy outputs

Policy is an area that we are addressing as part of our National Centre role. We have been participating in two Carbon Connect enquiries, providing input via the IET and EEF and having a key role in the Manufacturing Foresight project. To formalise our policy processes, we initiated a policy group at the annual conference. Our international policy work has included active support for UKTI in selling UK clean technology to Brazil, Russia, India, China and South Africa (the BRICS). The other main focus is a project with the United Nations Industrial Development Organization for the development of methodologies to enable ASEAN countries to create effective sustainable industrial strategies.

Other activities

We held our first Annual Conference, 'Leading from the Front', in Cambridge in September. There were presentations from a range of leading companies discussing their successes in developing sustainable activities and their priorities for the future, sparking interesting debates on opportunities for further collaborative research.

We have run a series of developmental programmes for the PhD cohorts of the Centre universities and also PhDs with aligned interests from other departments, universities and businesses. These have been widely acclaimed by the participants as an invaluable enhancement to their usual PhD activities.

More details can be found at www.industrialsustainability.org

CIS activities

ACADEMICS VISIT JAPAN

IfM members joined other UK academics on a trip to Japan to find out more about the country's approach to industrial sustainability. The visit was designed to help share experience and expertise; a UK based Seminar helped disseminate the findings.

INDUSTRIAL SYMBIOSIS

We are part of the academic community which supports the National Industrial Symbiosis Programme (NISP), brokering partnerships between those who produce waste and those who can use it as their input raw material.

Current and recent projects

PRODUCT RECOVERY MANAGEMENT

Using automated ID technologies to connect tagged items to a computerised network to support improved decision making about disposal or reuse of products at the end of their life cycle.

ASSET MANAGEMENT

Looking at ways to reduce the impact of physical assets on the environment throughout their life cycle by improved decision-making supported by better quality information, and developing tools to quantify the ecological impact of information.

CLEANTECH INNOVATION

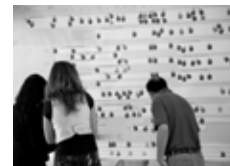
Understanding how the uptake of cleantech innovations (an innovation delivering the same service as a conventional alternative, but with less resource usage) is hampered by up-front costs and how this can be mitigated by financing solutions.

CORPORATE STRATEGY

A project examining the influence of macro sustainability trends and drivers on corporate strategy.

BUILDINGS FROM WASTE PAPER

Developing structural panels based on waste paper





for low-cost housing.

INDUSTRIAL SYMBIOSIS

Exploring examples of industrial symbiosis in the UK, EU and China, seeking to identify policy options that support implementation.

WIND TURBINES

Use of bamboo for wind turbine manufacture in China. Improving the carbon footprint and cost effectiveness of wind turbines. Design of a new generation of flexible wind turbines.

LANDFILL MINING

The use of landfills as a resource in developing countries and the technical, economic and social considerations of whether the contents of landfill sites can be excavated and materials reclaimed from them.

LONG RANGE PLANNING USING SYSTEMS THINKING

The aim is to improve the planning processes of manufacturing companies to better account for the demands and opportunities offered by sustainability.

NATURAL MATERIALS

Developing materials selection and processing routes to create high tech materials from sustainable resources such as bamboo, flax and stinging nettles. Quantitative assessment of the 'green' credentials of such materials.

DAYLIGHT SAVING, ELECTRICITY DEMAND AND EMISSIONS

Investigating whether changing the UK's clock policy and time-zone would result in a reduction of electricity demand and carbon emissions. In collaboration with the Department of Engineering and the Centre for Sustainable Development.

DEVELOPMENT OF SUSTAINABLE ENERGY POLICY

Developing an integrated framework for examining

sustainable energy policy, covering different perspectives (socio-technical, technical, societal) and timescales.

CORPORATE SOCIAL RESPONSIBILITY (CSR) IN FOOD MANUFACTURING COMPANIES

Focusing on the social dimension of sustainability in food manufacturing companies, where CSR is part of the business contribution towards sustainability.

POLYMER RECYCLING

Investigating novel, localised processes to transform polymer waste which is currently considered to be un-recyclable, into valuable, sustainable products.

SUSTAINABLE DESIGN AND MEDICAL DEVICES

Producing a tool for designers of medical devices to incorporate sustainability issues into their work.

SUSTAINABLE MEDICAL DISPOSABLES

Examining the potential for introducing biodegradable plastic disposables to create a more sustainable healthcare system.

ASSET MANAGEMENT INCORPORATING ENVIRONMENTAL VALUE

Developing frameworks to help determine combined environmental and economic impacts of asset decisions.

SUSTAINABLE DESIGN AND MANUFACTURE OF DOMESTIC APPLIANCES

Understanding the role that design can play in improving the social and environmental sustainability of domestic appliances.

SUSTAINABLE SUPPLY NETWORKS FOR INDUSTRIAL SYSTEMS

Extending the methodology of supply network configuration and design to the sustainability domain, enabling a holistic picture of the

environmental, social and economic impacts of industrial systems to be evaluated.

SUSTAINABLE VALUE

A collaborative European research project on new industrial models for sustainable and efficient production.

LIFECYCLE MANAGEMENT

Developing a strategic framework to assist industry in moving towards more sustainable product development, production and use of products.

DIRECT MEASUREMENT OF CO₂(G) EMISSIONS

Using a method of direct measurement to monitor CO₂(g) emissions from airports ground operations.

UNIDO

Integrating sustainability considerations into industrial policy development processes designed for developing countries.

SAKE

Sustainability assessment and knowledge exchange survey to help better understand the challenges of assessing sustainability in manufacturing enterprises and how to share knowledge between factories and companies.

PrISMS

Providing support for small and medium enterprises and early stage ventures helping them integrate sustainability considerations into their business to support sustainable growth.

CENTRE FOR SMART INFRASTRUCTURE AND CONSTRUCTION (CSIC)

www.centreforsmartinfrastructure.com

csic-admin@eng.cam.ac.uk

PEOPLE

Director: Paul Heffernan

Principal Investigator: Robert Mair

Academic staff: Julian Allwood, Roberto Cipolla, Jon Crowcroft, Marcial Echenique, Mohammed ElShafie, Ying Jin, Cecilia Mascolo, Duncan McFarlane, Campbell Middleton, Ajith Parlikad, Stefan Scholtes, Ashwin Seshia, Kenichi Soga

Researchers: Phil Catton, Rachel Cuthbert, Christos Efstratiou, Tariq Masood, Sarfraz Nawaz, Raj Srinivasan, Paul Vardanega, Jize Yan

Support: Paul Fidler, Phil Keenan, Peter Knott, Larissa Moore.

The IfM, and particularly DIAL, is active in this new University-based centre which focuses on the challenges of managing, maintaining and renewing the UK's physical infrastructure. In partnership with industry stakeholders, the multi-disciplinary Centre develops and commercialises emerging technologies in sensor and data management to enable radical changes in the construction and management of the nation's infrastructure.

CSIC has a wide range of projects underway. IfM involvement primarily relates to asset management.

KEY PROJECT

WHOLE LIFE MANAGEMENT OF INFRASTRUCTURE ASSETS

Making decisions regarding maintenance, refurbishment, renewal and investment in new assets based on optimised whole-life value

is critical for economic sustainability in asset-intensive industries. There is a growing demand for skills and tools to help resolve conflicts between short- and long-term costs and benefits, risks and other business drivers, particularly for ageing infrastructure facilities. This project is developing tools and guidelines for understanding capital and operational expenditure required to maximise the value generated by infrastructure assets. It examines how information from sensing technologies, and asset and operational information can be exploited to balance through-life costs and risks.

ACTIVITIES

Industry engagement

The Centre is partly funded by nearly fifty industry stakeholders, including asset owners and operators, construction contractors and consultants, and technology providers and developers. Engagement with these and other relevant commercial organisations is an important part of the Centre's activities. Workshops, conferences and symposia have been promoted by the Centre, to encourage interaction and knowledge exchange between academe and industry, and between diverse industry stakeholders.

Business Development

In conjunction with Cambridge Enterprise, the Centre focuses on the evaluation, development and exploitation of technologies and insights developed in the Department of Engineering, the Department of Architecture, the Computer Laboratory, and the Judge Business School. The Centre is tasked with commercialisation of research outputs, and with the establishment of a self-sustaining stream of future work.

FUTURE PLANS

The CSIC expects to receive new funding during 2013, to extend its collaborative research programme. The expansion will include further engagement with leading research groups outside Cambridge, and will extend the application and demonstration programme into the energy sector and newly-emerging infrastructure projects. The Centre will also launch a programme of training to support industry in the development of the skills and expertise required to implement smart technologies and practices.

MANUFACTURING INDUSTRY EDUCATION RESEARCH GROUP

www.ifm.eng.cam.ac.uk/mierg/

Programme Co-ordinator: Judith Shawcross
jks45@cam.ac.uk

Researchers: Tim Minshall, Tom Ridgman, Judith Shawcross, Manjusha Thorpe, Helen Zhang

MIERG is a recently formed group that is interested in educational issues related to manufacturing industry. It aims to research areas where new knowledge will benefit the learning and development of:

- **people** - in becoming effective and excellent practitioners in manufacturing industry roles
- **manufacturing industry companies** - in developing and sustaining the capabilities needed to compete in the global industrial ecosystem

PROJECTS

SCALE UP OF PROCESS INDUSTRIES

This project investigated the problems encountered during the scale up of manufacturing processes and identified the skills and knowledge that are needed for achieving successful scale up.

DEVELOPMENT OF COMPLEX WORKPLACE SKILLS

A study examining how students develop complex skills during the Industrial Systems, Manufacturing and Management MPhil Programme. A preliminary skills development framework has been developed and tested. Further work related to defining skill sets, improving student understanding of skill development and their reflective skills is underway.

INITIAL DEVELOPMENT NEEDS FOR TECHNICAL GRADUATES IN SMALL COMPANIES

A survey of small companies, mainly in the technology sector, to investigate their needs for graduate training and their response to the different formats for part time education.

STUDY OF FACTORS AFFECTING EMPLOYABILITY OF INDIAN ENGINEERING GRADUATES

A study of the fit between employer expectations, the experiences of recent engineering graduates, engineering students and the views of faculty to determine how well the Indian HE sector was producing engineering graduates for industry.

INDUSTRY EXPECTATIONS FOR NEW ENGINEERING GRADUATES IN THE UK AND CHINA

A comparison study of the views of engineering employers on new engineering graduates between Chinese industry and UK industry.

CULTURE AND LEARNING STYLES

This study looked at the learning styles of engineering students in the Middle East and compared them with studies of 16 other countries to see whether the learning styles varied with the country culture.

UNDERSTANDING THE SKILLS GAP IN STARTING A MANUFACTURING ENTERPRISE

While there is a lot of research and literature looking at how to get to the business plan stage of a start-up and how to run a small company, the gap between getting funded and establishing a stable

product supply is under explored. This project intends to investigate the skills needs for this period of business development.

THE INFLUENTIAL FACTORS IN CREATING A PRODUCT PORTFOLIO IN EARLY STAGE VENTURES

Many early stage ventures start with a single product, or service. This project looked at what factors influenced the drive to widen the product portfolio and when they occurred.

EARLY STAGE PRODUCTION SYSTEM DEVELOPMENT FOR PRODUCT BASED START-UPS

There were two linked projects looking at how start-ups went from an initial prototype product through to series production and how they made the necessary strategic production decisions.

INTERNATIONAL COMPARISON OF PERCEPTIONS OF ENGINEERING AMONG SCHOOLCHILDREN

This project examines national differences in the ways in which children in the 9-11 age range perceive engineers and engineering, and the impact this may have on choices of subjects studied at later stages of their education. The outputs of this project will provide support and guidance for policy initiatives that seek to improve the perception of engineering as a career and the uptake of engineering studies at the tertiary level.



Research degrees

www.ifm.eng.cam.ac.uk/education/phd
phd-enquiries@eng.cam.ac.uk

The Department of Engineering offers both one-year MPhil and three-year PhD research degrees and welcomes applications from high-calibre UK and overseas candidates. Potential research topics within the IfM encompass the full range of management, technology and policy issues covered by our research centres and interdisciplinary programmes. Student research either builds upon work in existing areas or develops along new avenues. The IfM has around 100 graduate and postdoctoral students.

PROGRAMME STRUCTURE

There are two main milestones during a PhD: the first-year report and submission of the final thesis at the end of three years. Students must demonstrate satisfactory progress at the end of the first year before they can continue with the final two years of the PhD. A supervisor is appointed for each student to provide direction and support throughout their research. Most students also benefit from the experience and knowledge of other members of the IfM. Students on the MPhil programme undertake a one-year period of supervised research, leading to submission of a thesis. Some MPhil students go on to complete a PhD.

Both PhD and MPhil students are given training in research methods. The IfM hosts the annual two-day Research Methodology Workshop for PhD researchers with interests in management or policy related disciplines. A small sample of current PhD projects is given below.

SELECTED PROJECTS

Manufacturing excellent engineers

IfM has been 'manufacturing' excellent engineers through its undergraduate and master level programmes for many years. A differentiating feature is assumed to be the experience gained

by the students via industry-based projects, visits and exercises. However, the contribution of these kinds of experience to a students' learning is not fully understood. This project investigates their contribution and the resource requirements to deliver them.

Judith Shawcross: jks45@cam.ac.uk

Identifying the business case for managing risks associated with sustainability

Long term impacts associated with sustainability issues (such as climate change and resource depletion) form a relatively marginal threat to most organisation's business strategy at present. However, evidence from some industries suggests that successful implementation of roadmapping and foresight tools to develop a long term strategy improves resilience from these risks and even enables them to capitalise on opportunities ahead of their competitors.

Elliott More: egm27@cam.ac.uk

Reducing rare earth consumption in Neodymium-Iron-Boron magnets

The Neodymium-Iron-Boron magnets often found in electric vehicle motors and wind turbine generators use large quantities of rare earth elements. In response to the steep price rises and

critical supply of these elements over the last decade, the EC funded Hi-Wi project aims to reduce their consumption by taking advantage of the unique magnetic properties of finely controlled nano-composite structures in collaboration with a consortium of industrial and academic partners.
David Hopkinson: dmh48@cam.ac.uk

Investigation of laser matter interactions using high power tunable ultrafast Ytterbium fiber lasers

Laser manufacturing is dominated by several laser sources at traditional lasing wavelengths and long-pulse interactions. Industrial processes have been optimised using these available laser sources, but relatively little work has been undertaken to optimise the laser parameters to the process. In this project we aim to break beyond the bounds of current laser technology and investigate the performance of novel laser sources developed by a well-established consortium of academics and industrial partners.
Krste Pangovski: kp358@cam.ac.uk

Product intelligence in supply chain operations: a game theoretical approach

Recent studies show that risk management is one of the biggest challenges faced by supply chain managers and monitoring disruptions is the area they will focus on most in the next few years. At the same time, today's customers are playing an increasingly important role in the design of supply chain operations as they demand better visibility and control of their orders. In this study, we explore how the evolving industrial control paradigm of product intelligence can help an organisation respond to these challenges. The approach seeks to give customers greater control over the processing of an order using methodologies which allow them to influence dynamically the way the order is produced, stored or transported.
Vaggelis Giannikas: eg366@cam.ac.uk

The role of location in open innovation implementation in UK high-tech SMEs

Open innovation has emerged as a new paradigm in innovation research. How does a collaborative approach to innovation compare to more traditional closed-off, internal product development? This research focuses on open innovation in small and medium-sized enterprises, the role of location in innovation implementation and sources of openness in innovation activities, with a special focus on UK high-tech clusters.
David Weiss: dw368@cam.ac.uk

Impact of innovation management consultancy services on the R&D and marketing relationship

Consultants may promote organisational changes inside companies they work for. But, how can the impact of management consultancy services be measured? This research aims to determine the potential impact of consultancy services on the relationship between R&D and marketing in large companies. The results will provide insights into the conditions under which consultancy services could improve the R&D/marketing relationship and ways to measure such improvement.
Luzselene Rincon: lr353@cam.ac.uk

APPLICATIONS

Admission to Cambridge research degrees is managed by the University's Board of Graduate Studies. Full details of how to apply can be found on their website:

www.admin.cam.ac.uk/offices/gradstud/

Information specific to the Department of Engineering can be found at:

www.eng.cam.ac.uk/graduate/postgrad/

Applicants are encouraged to discuss their proposed research topic with the IfM research centre concerned. Some funded studentships are available but early application is strongly advised.



Undergraduate: Manufacturing Engineering Tripos (MET)

www.ifm.eng.cam.ac.uk/met
met-enquiries@eng.cam.ac.uk

MET is an option for the final two years of the Cambridge Engineering degree. The course develops and applies engineering knowledge in a business context and prepares students to be leaders of business and technology enterprises. It provides a thorough grounding in management and manufacturing technologies, together with an understanding of the full range of industrial activities – from market analysis, product design and production, right through to sales and distribution. MET recently underwent a full course review and update.

PEOPLE

Course Directors: Bill O'Neill, James Moultrie

Academic staff: Claire Barlow, Mike Gregory, Paul Heffernan, Ian Hutchings, Duncan McFarlane, Tim Minshall, James Moultrie, Bill O'Neill, Ajith Parlikad, Jim Platts, Ken Platts, David Probert, Alan Thorne

Support: Sinead Hurley, Ann Grady

COURSE STRUCTURE

Students take a diverse set of modules that span all issues of relevance to manufacturing businesses, from market analysis, product design and production, right through to sales and distribution.

INDUSTRIAL PROJECTS

The programme's taught course is combined with repeated opportunities to put theory into practice via a series of industrial projects. Final-year students work in small teams on three company-based projects, tackling real industrial problems. In addition, a six-week individual project takes place

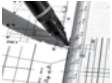


at the end of the year. Examples of recent industry projects include:

Redesign of high volume electric motor assembly facility (Global consumer goods company)

Rationalising communication of shop-floor generated information (Multinational engineering company)

Streamlining of vendor supply chain processes (High performance engines manufacturer)

Developing a plan to introduce preventative maintenance for advanced drilling equipment (Aircraft manufacturer)

MET		Designing a product		Making components		Organising the factory		Managing the business		Business context
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Optimising product allocation to automated assembly (Lighting manufacturer)

Developing manufacturing strategy for new single crystal turbine blade facility (Global engineering company)

Customer satisfaction and new product pricing strategy (Independent energy company)

Implementation of inventory forecasting (High performance engines manufacturer)

Development of a visual management display system (Food equipment manufacturer)

MAJOR PROJECT

Students undertake a major design project during their first year. Students work in teams of three or four to research the market for a product, prepare a design and manufacturing plan and finally draw up a business plan for a company to produce the product. Each year these are displayed at a Design Show in June. One of the product ideas on display at the 2012 event, the Rotary Cone, has already been recognised by the food-processing industry as a potential solution to the complicated and expensive problem of lump removal. Other products included Medibox, a solution for the transportation and monitoring of temperature sensitive medical substances and a hi-tech leg protection system for polo ponies.

www.ifm.eng.cam.ac.uk/education/met/a/design/

GRADUATE RECRUITMENT

MET graduates are well positioned for leadership roles in business and industry. MET graduates are employed across the whole value chain from design, operations, business development, consultancy and government.



INTERNATIONAL RESEARCH PROJECT

Final year students travelled to South Korea in the summer of 2012 to investigate this economic powerhouse and, in particular, how it is approaching both its economic and environmental sustainability.



Postgraduate: Industrial Systems, Manufacture and Management (ISMM)

www.ifm.eng.cam.ac.uk/ismm

ismm-enquiries@eng.cam.ac.uk

The MPhil in Industrial Systems, Manufacture and Management (ISMM) is a one-year postgraduate programme designed to provide graduates with the technical skills, personal development and industrial experience they need to become immediately effective in their early careers in industry. It consists of a mixture of taught course modules, around 40 company visits, a series of projects tackling real business and technical problems in industry and an in-depth, individual research project. ISMM also includes a 2-week study tour providing experience of industries outside the UK. The course is highly competitive and attracts five applicants for every place. Each cohort typically includes around 15 different nationalities.

PEOPLE

Course Director: Simon Pattinson

Tutors: Tom Ridgman, Yongjiang Shi

Associate Tutors: Nicky Athanassopoulou, Derek Ford, Gerry Frizelle, Peter Hiscocks, Finbarr Livesey, Tim Minshall, John McManus, Vanessa McNiven, Bill O'Neill, Dominic Oughton, Judith Shawcross, David Schwarz, John Sullivan **Support:** Sue Gaw, Samantha Archetti



COURSE STRUCTURE

ISMM runs for 45 weeks and comprises eight weeks of project work, sixteen weeks of taught modules, a two-week overseas study tour either in mainland Europe or further afield and a sixteen week dissertation project.

ISMM is not just an academic course – the emphasis is on learning by doing and on solving real problems in live industrial situations. Each cohort undertakes a total of 120 industrial projects.

INDUSTRIAL PROJECTS

Small teams of students work on four company-based projects, each lasting two-weeks, tackling real industrial problems. At the end of each project they present their findings to senior management. Recent projects have included:

Audit and evaluation of company's carbon footprint (Market leader in food/drink vending sector)

Factory layout for new concept single-seater light aircraft (Entrepreneur)



- Market research and analysis of a novel magnetic tagging platform technology** (High tech start-up)
- Hi-Fidelity playback of music in a 'streamed' world** (High-end market leader in the audio sector)
- Process improvement in television programme planning** (Specialist media company)
- Improved stock management for orthopaedic surgery** (Major teaching hospital)
- Further development of Lean Manufacturing Systems in a fast moving production environment** (Subsidiary of a multinational manufacturing business)
- Mapping the governance process for manufacturing technology programmes** (Major aerospace company)
- Global manufacturing strategy** (International wind turbine company)

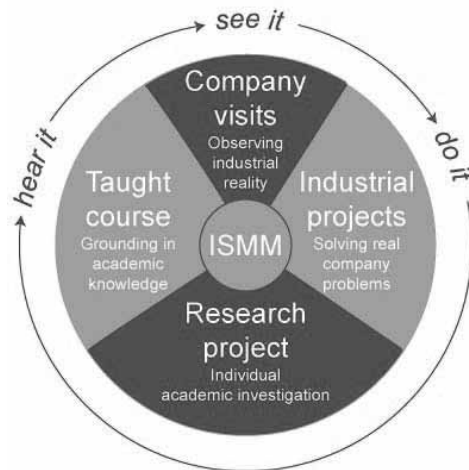
OVERSEAS STUDY TOURS

Each summer the students divide into two groups and go on two-week study tours. In 2012 one group visited northern Italy and the western seaboard of Turkey to explore the contrasts between a country feeling the strain of economic hardship and financial crisis on the one hand, and, on the other, a country which has seen a rapid increase in manufacturing activity thanks in part to generous state incentives and support.

The second group visited the east coast of China which has been enjoying a new manufacturing boom as companies strive to transform from low labour cost driven production to a more innovative and higher value-added manufacturing model.

LEADERSHIP DEVELOPMENT

ISMM students spend two weeks on the development of leadership and management skills, including outdoor team exercises in the Lake District. The students learn how to complete tasks through successful teamworking and how to lead their peers in problem-solving activities.





IfM Education and Consultancy Services (IfM ECS)

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

ifm-enquiries@eng.cam.ac.uk

IfM Education and Consultancy Services provide a rapid dissemination route for new ideas and approaches developed at the IfM. Industrial practitioners, with many years of senior management experience, engage directly with industry, governments and other agencies via consultancy, executive education and events. Their approach is very different to conventional consultancy – they work collaboratively to co-develop solutions and focus on transferring knowledge as well as delivering business results. Their engagements help to both inform and fund future IfM research.

PEOPLE

Director: Peter Templeton

Industrial practitioners: Nicky Athanassopoulou, Paul Christodoulou, Bill Colquhoun, Bernhard Dusch, Gavin Farmer, Don Fleet, Derek Ford, Andrew Gill, Philip Hemsted, Jonathan Hughes, Duncan Hurlstone, Imoh Ilevbare, Andi Jones, David Learmond, Dennis Lewis, Steve Mann, John McManus, Dominic Oughton, Tony Prouse, Michèle Routley, Liz Salter, Martin Smith, Nick Sullivan, John Thomas, Jim Trueman

Events management: Ella Davey, Jo Griffiths, Lauren King

Executive education and tool development: Alan Cousens, Tom Ridgman, Judith Shawcross

Marketing and communications: Sarah Fell, Nick Mann, Samantha Selvini

Finance: Linda Gray, Neil Hickinson, Maija-Liisa Walker

Administration: Katherine Harding, Anna Rowntree, Kate Willsher

PUBLIC SECTOR

www.ifm.eng.cam.ac.uk/services/overview/government/

Future of UK high value manufacturing

IfM ECS has continued to work with the Technology Strategy Board's (TSB) High Value Manufacturing team to develop the UK's 'High Value Manufacturing Landscape'. In February 2012 IfM ECS published a major report identifying important trends influencing the changing nature of manufacturing, and considering the greatest challenges and opportunities manufacturing firms

are likely to face – captured in five strategic themes.

The report recommended that key sectors should be explored in greater depth and IfM ECS has been working with the Health and BioSciences Knowledge Transfer Networks in Pharmaceuticals, Food and Medical Technologies and BioPharmaceuticals to develop roadmaps for these key sectors ('deep dives').

The UK life sciences manufacturing landscape

The first of these, a new study aimed at identifying needs, opportunities and challenges in the UK pharmaceutical and biopharmaceutical



manufacturing sectors, was published in November 2012. The report is available to download at: www.ifm.eng.cam.ac.uk/resources/government/the-future-uk-life-sciences-manufacturing-landscape/

Roadmap for synthetic biology

The UK government has identified synthetic biology as an emerging technology which could tackle global challenges in areas such as healthcare, energy and the environment and which has the potential to become a billion-pound industry for the UK within the next ten years. For its potential to be realised, the government wants to ensure that there is a clear – and shared – sense of direction and a robust and responsible ethical framework in place. In 2012 IfM ECS ran a series of roadmapping workshops attended by more than 70 experts from industry, academia, government, the research councils and the TSB. A report outlining the findings and recommendations was published in July 2012.

Algal bioenergy

Although there is some evidence that we may be able to produce biofuels from algae on a large scale, there are also concerns particularly around environmental impact. The Natural Environment Research Council (NERC) and TSB are jointly funding an assessment of the opportunities and risks of developing algal bioenergy and asked IfM ECS to run two workshops to roadmap the likely timeframe and actions required to establish a globally competitive algal biotechnology industry in the UK.

Robotics and autonomous systems

Robotics and autonomous systems have been identified as one of the eight future technologies which ‘will revolutionise our economy and society over the next 20 years’. Currently, the UK’s activities in this area, although world-class, are

dispersed across different universities, companies and market sectors. The TSB and the Electronics, Sensors and Photonics, Aersospace, Aviation and Defence and Industrial Mathematics Knowledge Transfer Networks are working together to foster collaboration and focus on the needs and capacity of the UK industry. IfM ECS has carried out a roadmapping exercise to create a shared vision of the sector’s future development.

SELECTED PROJECTS LARGE COMPANIES

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

Roadmapping

The IfM has developed and deployed roadmapping techniques in a wide variety of situations to help companies and industry sectors develop business strategies which link both to market trends and opportunities and to product and technology developments. In 2012, IfM ECS carried out a number of roadmapping projects.

The Food and FMCG sectors were a particular focus of activity. As part of our work with the Open Innovation (OI) Forum (see page 40), we developed an overarching roadmap for the sector as a whole. As well as providing a clear picture of the future direction of the sector, the roadmap has also enabled the OI Forum to establish a linked series of agendas for 2013 which will deliver maximum value for the participants in addressing the drivers and opportunities identified by the roadmap. IfM ECS also ran roadmapping projects with some of the individual OI Forum members to explore their technology and innovation needs in packaging for healthcare, food and beverages and in household and personal care.

Other projects included training a major Mexican oil company in roadmapping techniques and working with them on technology intelligence and



portfolio management. A Malaysian car producer asked us to help set up an annual roadmapping programme and we continue to provide them with ongoing support as the roadmapping process is developed and rolled out. IfM ECS has also worked with a relatively new global organisation involved in educational software packages and a major global chemicals company.

We carried out project to help with the design of a new product for a large engineering company. This started with roadmapping to agree the need and functionality requirements then we used the tools developed by IfM's Design Management Group to help write a design brief which the company used to appoint a design agency.

IfM ECS has been working extensively with a major international aerospace and defence supplier to apply roadmapping tools and benchmarks of Strategic Workforce Planning (SWP) capability to the development of a UK-wide SWP process. This has involved working with a variety of major UK-based engineering companies and the design and testing of client-specific SWP processes, previously developed in a pilot with one of the clients and further developed based on the benchmark findings.

Capturing Value from Global Operations Networks

During 2012 we have focused on integrating and extending the various consulting tools that have emerged from research in the Centre for International Manufacturing over the last ten years. The combined toolset responds to the key challenges associated with managing complex operations.

Global Value Networks - supports analysis of complex industrial landscapes leading to the design of optimised supply chains that support evolving industry structures. The tools have been applied at industry as well as firm levels. One recent

industry-level application involved the mapping of the emerging industrial biotechnology value chain in the UK, leading to recommendations for accelerated development and optimisation. Another key project is focused on the restructuring of the pharmaceutical industry to fit new continuous process technologies.

End-to-End Supply Networks – focuses on optimising the capability and configuration of a firm's overall 'physical' supply network (covering supply management, production and routes-to-market). They use high level visualisation techniques and structured capability assessments to help senior executives formulate enterprise-wide strategy. During 2012 these tools have been applied in three multinationals in aerospace, telecoms equipment and toys. Our case-library now includes more than 30 major multinationals.

Global Production Networks – focuses on optimising complex plant networks and helping firms to 'make the right things in the right places'. This is based on longstanding IfM research across a number of linked areas including roadmapping, make-or-buy, global network design and manufacturing mobility. The tools have now been applied in 13 major multinationals in the last 10 years with recent applications in white goods and industrial printing equipment.

Additional tools are available in this suite that focus on Global Engineering and Service Networks, as well as related themes such as Mergers and Acquisitions, and Supply Chain Risk/Resilience. Consulting in this area is closely integrated with ongoing research and involves close partnership with collaborating companies to help tailor and embed innovative strategic tools that can support sustainable competitive advantage via optimised global networks. We also facilitate a small community of senior industrialists to share best practice and to contribute to setting the future



research agenda.

Open Innovation Forum

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

Now in its third year, the Open Innovation Forum has gone from strength to strength. Aimed at firms involved in the Food & Fast Moving Consumer Goods (FMCG) sector it is concerned with the complete value chain, from raw materials and packaging suppliers to equipment manufacturers, through to logistics organisations and retailers. Forum members share best practice, explore 'hot topics' along the FMCG value stream and participate in optional, accelerated collaborations.

By the end of 2012 the Forum already had 14 members. The members shared their successes and challenges in a number of key areas such as how to work effectively with SMEs; what to consider when choosing OI partners; and balancing risk and reward in OI collaborations.

The Forum's perspective along the entire value chain has enabled members to explore some of the 'grand challenges' that face the Food and FMCG sectors. One of the most pressing themes under discussion has been sustainability, including the reduction of energy, water and waste as well as understanding the implications (and opportunities) for sustainable brands.

EXECUTIVE DEVELOPMENT

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

IfM researchers and IfM ECS practitioners design and deliver bespoke programmes to meet strategic and capability development needs. Active learning techniques are used to embed new knowledge and skills. This includes group projects to tackle key strategic issues that deliver tangible benefits to the company.

Executive innovation programme

In 2012 IfM ECS delivered a study mission for a Taiwanese Non-Governmental Organization which provides overseas training courses for executives from manufacturing companies. The mission comprised a series of workshops which explored strategies to support local firms making the transition from supplying components to designing and developing higher value products and systems. In 2013 IfM ECS will follow up the programme with a series of seminars in Taiwan.

Managing technology development

IfM ECS collaborated with a Finnish institute on a course for senior managers. This course addressed the challenge of managing technology development and included visits to local business incubators, learning from successful business start-ups.

Global partnership delivering new executive programme

In the spring of 2012 IfM ECS delivered the second presentation of a programme for a leading international company which manufactures equipment for construction and power systems. This programme forms a key element in an integrated management development initiative in which IfM ECS is partnered with leading universities in Asia and the USA. Managers attend courses in economics, finance, marketing, leadership and strategy at the IfM in Cambridge. The third and fourth presentations of this programme will take place in Spring and Autumn of 2013.

SELECTED PROJECTS MID-CAP COMPANIES

Strategy Development

IfM ECS has a set of well-established tools that were originally designed to help small and medium sized manufacturers develop strategy and build capabilities. These tools, and their delivery, are





based on techniques which acknowledge both the lack of time for senior management to work 'on' their business as well as 'in' their business, and the uncertainty that often exists on how best to approach these issues. These characteristics are not unique to very small businesses, and there have been a number of successful projects in 2012 applying these approaches in larger mid-cap companies.

A Cambridge-based technology company, with a diverse acquired product range, and five manufacturing sites (including China and North Africa) engaged IfM ECS to work with them in developing a clear business strategy. Our workshop-based approach led to the definition of a clear product market group structure, included a detailed review of competences across the whole business, and then identified priority areas and projects to deliver aggressive growth plans.

Prioritisation was applied for a large, privately owned Indian business which designs and manufactures instrumentation in the UK and in two Indian sites. The structured prioritisation approach enabled consistent comparison of priorities and capabilities between and within separate business units, and also between functions in different locations. Two key capability areas were identified as barriers to growth, and this then led to further capability work with the same business. The IfM ECS 'Speeding New Products to Market' tool included a survey of over 100 members of staff involved in new product introduction, and was a key element in work to produce a clear framework of recommendations for high impact improvement activity. In addition to this, the 'Supply Chain Capability Assessment Tool' has been used to provide an evidence-based approach to developing tailored training for key individuals in the supply chain function.



SELECTED PROJECTS

SMALL COMPANIES

www.ifm.eng.cam.ac.uk/services/overview/sme

UK-wide support programme

Managers of small and medium-sized manufacturing (SME) businesses have little time to think beyond the immediate day-to-day challenges of keeping the firm on track. When problems arise, they are often too busy fire-fighting to be able to identify the real causes of any problem and prevent it happening again. But such problems must be addressed if the business is to flourish. In the past managers of such businesses have had to rely on large company tools and techniques to help them address their problems. However, this approach assumes that small companies are essentially small large companies.

Over the last 11 years we have worked with over 700 SMEs, helping them develop their strategy and build capabilities. During that time we have developed a unique tool set which has been specifically developed for the SME manufacturing environment. Our approach takes a whole-company view and typically consists of three phases:

1. A one-day diagnostic which uses a structured question set to reveal the firm's priority areas leading to the development of a tailored plan to develop capabilities and achieve real improvement.
2. Four half-day business strategy development workshops which typically identify new market or product opportunities; how the firm should compete; and a prioritised action plan for executing the strategy.
3. Half-day capability development workshops and capability assessment tools help the firm build its ability to win orders and manage the firm's resources more effectively to achieve its growth

ambitions.

Over the last twelve months the SME team has grown and now has the capability to engage with companies throughout England and Wales.

CASE STUDIES

Company A grew from 10 employees to 45 over three years.

Company B trebled its productivity and now employs over 40 (from 8). Turnover is expected to grow from £250K to £5m in this financial year.

Company C improved sales by 30% (with the same workforce), effectively increasing GVA and GVA/employee by the same margin.

Company D has increased sales by approximately 40% over the last three years.

Company E doubled its volume and employment has risen from 22 to 40 over the last three years.

Company F increased the workforce by 10 over the last two years and is now looking to grow further.

A new guide to our manufacturing transformation programme is available from IfM ECS, entitled Help for Smaller Manufacturers.

PrISMS

In 2012 we launched the PrISMS (Practical and Innovation Solutions for Manufacturing Sustainability) programme funded by the European Regional Development Fund and other funding agencies to support the sustainable growth and development of 50 start-ups and 70 SMEs across Eastern England. The programme aims to help companies:

- grow revenues and profitability
- make their products and operations more sustainable
- create new jobs and safeguard existing ones in the firms taking part and across their supply chains

For further information on this programme, see: www.ifm.eng.cam.ac.uk/services/prisms/

IFM MEMBERSHIP

www.ifm.eng.cam.ac.uk/services/overview/membership/

IfM corporate partnership scheme

The Corporate Partnership Scheme provides companies with access to research-based strategic, technical and business expertise, geared to the specific needs of large international companies. Twenty companies are currently members of the scheme.

SME membership scheme

The IfM's membership scheme for small and medium-sized companies currently has over 50 members. Membership provides access to expertise in strategy and capability development, with support geared to the specific needs of small and medium-sized companies. Members pay a reduced charge for IfM services, training programmes and workshops.

The IfM Open Evening provides an opportunity for members to learn about the latest work of the Institute, and the annual garden party for members, held in one of the Cambridge Colleges, provides an opportunity to network.

COURSES AND EVENTS

www.ifm.eng.cam.ac.uk/events/

Workshops

Over 1,000 people attended IfM events in 2012. Our programme of workshops and courses presented research-based approaches on a range of manufacturing management themes. These included roadmapping, technology and innovation management, make-or-buy, technology



evaluation, performance management, technology intelligence and fundamentals of manufacturing management.

SME workshop programme

A programme of workshops, specially designed for smaller manufacturing companies, ran throughout the year. In spring, a series of six workshops, 'Building better businesses' for senior managers, focused on key issues related to winning orders or managing limited resources.

In June, workshops looked at 'Purchasing and supply management: a strategic approach', and 'Improving the overall effectiveness of the procurement process'.

The 'Fundamentals for Manufacturing Management' series for supervisors has been running since 2001, and remains popular.

The workshops are tailored to meet the needs of busy managers, and are designed to stimulate lively discussion about practical steps that can be taken to strengthen and grow small businesses.

Industrial Briefing Day

Over 100 senior managers from industry attended a Briefing Day in May 2012. The event provided an opportunity to meet leading researchers in management, technology and policy areas and showcased some of the IfM's recent industrial collaborations. The next Briefing Day will take place on 21 May 2013.

www.ifm.eng.cam.ac.uk/events/ifmbriefingday/



IDEASPACE

www.ideaspace.cam.ac.uk/

ideaSpace exists to create the best community for, and environment to support, the creation of new ventures in Cambridge.

Part of the University of Cambridge, ideaSpace not only supports University innovation, but also supports the wider entrepreneurial community. Providing an environment that brings together people from the University, industry and society, ideaSpace members create the leading ventures of tomorrow.

Created in 2009 through funding from the Hauser-Raspe Foundation and the East of England Development Agency, ideaSpace opened its co-working space in the Hauser Forum in June 2010 and as of January 2013 has a membership of 115 people engaged in 75 resident ventures, and over 30 alumni ventures.

ideaSpace is supporting the IfM ECS PrISMS sustainable business growth programme, using its understanding of the needs and aspirations of Early Stage Ventures (ESVs) to inform the development of structured business tools to support the sustainable development and growth of ESVs. ideaSpace members engaging in the PrISMS programme are offered support to help evaluate promising opportunities; develop their business strategy; create their business; and scale-up their business capabilities.

Over the next year ideaSpace will open its second facility, located in the centre of Cambridge, and engage with a wider range of University Departments and sectors to help catalyse and support more ideaSpace Members and the industries they seek to make an impact on.

Public engagement



Cambridge University Science Festival

The IfM took part in Cambridge University's annual Science Festival once again in March 2012. This highly popular event is now a firm fixture in our annual calendar. Activities included tours of the IfM's Photonics Labs to see lasers cut through thick steel and engrave the head of a live match without setting it alight.

In the Automation Labs young visitors had fun trying to race the team of robots at puzzle solving – while finding out about the myriad of ways that robots are used in modern factories. Meanwhile the IfM's Inkjet Research Group showed how light flashing at a particular frequency can make water drops appear to be 'frozen' in mid air.



Tim Minshall gave a talk on the importance of making mistakes – showing how blunders have led to some of the greatest inventions. Bill O'Neill, introduced his young audience to the 'wacky world of lasers.' A team from the Cambridge Science Centre brought a preview of their exhibits for visitors to try out and give feedback while i-Teams showed new technologies from companies and invited children to think of ways they could be used.

The 2013 Science Festival runs from 11–24 March. The IfM events take place on the afternoon of Saturday 23 March, featuring some old favourites plus lots of new items as well.

Changing children's perceptions of engineers

Dr Tim Minshall also gives regular talks at local schools to enthuse primary school children about the creative and innovative aspects of what engineers do and challenge their perceptions

of engineers as men in hats who fix things with spanners.

As a result of his work in this area, Tim was invited to give a TedX talk on children's perceptions of engineering. The success of this talk prompted producers of a BBC children's programme, *Nina and the Neurons Go Engineering*, to contact Tim for some advice on how to explain tricky concepts such as how computers and mobile phones work to five year olds. Tim enlisted the help of a group of MET students and their suggestions were sent to the show's producers.

Watch Tim's TedX talk at: <http://bit.ly/V2h8Cy>

School children get an introduction to manufacturing

Twenty-nine children from a Chelmsford secondary school spent a day at the IfM in July 2012, having fun and learning about manufacturing engineering. The students from the specialist engineering college, Chelmer Valley High School, who are studying for their GCSEs, took part in the crane construction challenge - a hands-on task which needs skill and good understanding of key engineering principles to build a load bearing crane, using only paper and cardboard tubes as raw materials. They also played the 'just-in-time' game – a fun session designed to teach operations management.

Suzanne Mycock, Head of Engineering at the school said: "Our students have thoroughly enjoyed all the activities and they now have an informed and more realistic impression of what engineering is all about."

Sixth formers tour the IfM

Two award winning sixth form students visited the IfM in October 2012 as part of a week's placement with British Sugar. The pair won the placement as their prize in the Academy Award Excellence competition. During their visit, the students, Emma Carter from Valley Invicta Academies Trust and Harmandeep Singh from Thomas Deacon Academy toured the IfM's automation labs and design studios and also had the chance to discuss industrial sustainability with IfM researchers and to contribute their ideas on outreach activities.

Visitors to the IfM

The IfM welcomed a number of distinguished visitors to the Alan Reece Building in 2012.

In May, Sir Michael Marshall, **Chairman of the Marshall Group**, opened the Marshall Gallery at the IfM to display a collection of photographs depicting some of the Marshall Group's outstanding manufacturing achievements such as Concorde's famous 'droop nose', designed and built in the 1970s. The gallery was opened in recognition of the Marshall Group's generous donation to help fund the Alan Reece Building.

In October, the IfM welcomed the Rt Hon Dr Vince Cable, **Secretary of State for Business, Innovation and Skills**. He was given an overview of the IfM by Mike Gregory, and met some of its key researchers with interests in policy, technology management and international manufacturing. He was also given a tour of the IfM's robot and laser laboratories before taking part in a question and answer session with fourth-year undergraduates on industrial strategy. Before leaving, he participated in a roundtable discussion with the Vice-Chancellor of the University and a group of Cambridge academics on the 'Cambridge ecosystem and growth'.

Mr Ashok Thakur, **Special Secretary of the Department of Higher Education in India's Ministry of Human Resource Development**, also paid IfM a visit. He was here to learn about the University's education and research system and to discuss India's new higher education initiatives. India is establishing a number of new autonomous Innovation Universities, which will aim to compete with the world's best academic institutions. His visit to Cambridge was organised by the British Council's UK India Education and Research Initiative (UKIERI).



Publications and online resources

The IfM produces a range of publications and online resources based on its work with industry.



Practice guides and reports

Most of our practice guides and reports are available for free download. They include:

- Making the right things in the right places
- Organising for breakthrough innovation: rejuvenating the established firm
- Technology acquisitions

www.ifm.eng.cam.ac.uk/resources/reports/

Briefings

IfM Briefings provide a two-page introduction to a range of management, technology and policy issues. Briefing topics include:

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IfM Briefings are available for free download from our website.

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Books and workbooks

The IfM publishes a range of practical workbooks and textbooks based on collaborative research with industry. Titles include:

- Roadmapping for strategy and innovation:

Aligning technology and markets in a dynamic world

- T-Plan: the fast start to technology roadmapping: Planning your route to success
- Technology intelligence: Identifying threats and opportunities from new technologies
- Make-or-Buy: a practical guide to industrial sourcing decisions
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The Institute for Manufacturing (IfM) provides a unique environment for the creation and sharing of new ideas and approaches to modern industrial practice. The IfM takes a distinctive, cross-disciplinary approach to global industrial issues, integrating research and education directly with practical application in industry.

Part of the University of Cambridge's Department of Engineering, the IfM brings together expertise in management, technology and policy to address the full spectrum of industrial issues. Research is undertaken in close collaboration with companies, ensuring its relevance to industrial needs. Industrialists contribute to our education programmes and host company-based projects, giving students experience of demanding, real-world problems.

The IfM's research findings are disseminated by the University-owned company IfM Education and Consultancy Services. Experienced practitioners work with industry, governments and support agencies to apply research-based tools and techniques. This provides a rapid dissemination route for new ideas and helps to inform and fund future research.

The IfM's broad expertise and integrated approach underpins its leading role in supporting industrial innovation and its contributions to the debate on manufacturing's role in a successful economy.

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