EPSRC/DST India Workshop in

Advanced Manufacturing Research Challenges

Delhi and Mumbai, India – January 2012

Creating and enhancing the global impact of UK and Indian manufacturing partnerships

Event Report

EPSRC
Engineering and Physical Sciences Research Council

RESEARCH COUNCILS UK INDIA

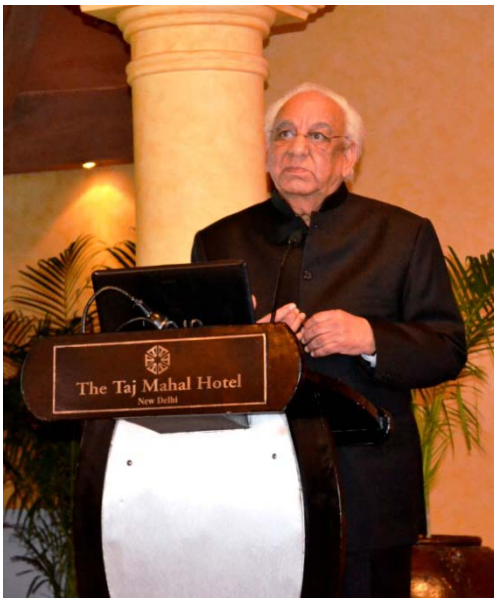
Department of Science and Technology

Contents

A selection of workshop speakers, from left to right:
Professor B. Ravi (IIT Bombay), Professor Nigel Titchener-Hooker (University College London), Dr. Baldev Raj (President, Indian Academy of Engineering), and Professor Richard Hague (Loughborough University).

Overview

Twenty-first century manufacturing is an increasingly global endeavour, driven by the rapid pace of technological change.



Dr. V. Krishnamurthy, Chairman, National Manufacturing Competitiveness Council

High-value manufacturing processes are increasingly moving towards flexible, intelligent production systems that involve the inter-play of novel technologies, advanced materials, in-line analysis and ICT, dual working of people and automated systems, and precision engineered products and systems. Vital to all industrial sectors, modern manufacturing is more than merely production – it encompasses R&D, design, prototyping, production, distribution, service and support provision, and end-of-life repair, recycle or reuse.

Both the Engineering and Physical Sciences Research Council (EPSRC) and the Department of Science & Technology (DST) play a pivotal role in promotion of science and engineering in their respective countries. The challenge for EPSRC's *Manufacturing the Future* challenge theme is to create, capture and accelerate the benefits from groundbreaking research for future UK manufacturing. Manufacturing businesses compete in international markets, and their supply chains and competitors are often global. Research also performs within a global context and, therefore, there is considerable scope to increase the alignment between global research and global manufacturing.

Professor Sir Mike Gregory, Institute for Manufacturing, University of Cambridge

Workshop delegates were welcomed by Mr. James Bevan CMG, British High Commissioner to India, and Dr. T. Ramasami, Secretary to the Government of India, Department of Science and Technology. Dr. Ramasami highlighted the importance being given to the manufacturing sector by the government of India, since it acts as a catalyst for economic growth and employment generation. He also remarked that the recently launched National Manufacturing Policy aims to increase manufacturing activity from a current 16% GDP to 25% by 2022. This equates to a growth rate of 12-14% per year, and aims to generate 100 million new jobs in India.

Mr. Bevan highlighted the UK Government's policy of enhancing economic growth built around the growth in the manufacturing industry sector. The UK's coalition government has also placed manufacturing at the heart of the economic recovery, and has published a series of policy announcements and reviews on the subject. EPSRC and the Technology Strategy Board support

research and innovation in manufacturing *via* several routes, including the EPSRC Centres for Innovative Manufacturing, and the High Value Manufacturing Catapult.

The workshop was inaugurated by Dr. V. Krishnamurthy, Chairman of the National Manufacturing Competitiveness Council, Government of India. He strongly supported a UK/India initiative in advanced manufacturing, and stressed the recently formulated Government of India National Manufacturing Policy, which recognises the challenges and opportunities in manufacturing across industry sectors, particularly in relation to skilled and innovative manpower.

The Workshop

Given these strong alignments, EPSRC and DST have committed to work together, facilitated by Research Councils UK India and the Science & Innovation Network, India. A UK delegation was invited to attend a two-day challenge-scoping workshop, to be held in Delhi during 30-31 January, 2012 and followed by a visit to an Indian manufacturing establishment (namely Larsen & Toubro, Mumbai, India) on 1 February, 2012.

Dr. Baldev Raj (Indian Academy of Engineering) and Dr. Alicia Greated (RCUK India).

A total of twenty-three UK delegates, from academia and industry, attended the workshop. They worked, alongside thirty-nine Indian delegates,[1] through a three-day programme of presentations, structured discussions, open networking, and site visits.[2] This was designed to coalesce the delegates' thinking around shared research challenges that were identified as being of interest to both industry and academia in both the UK and India.

At the conclusion of these intensive deliberations, seven mutually-agreed research challenges were identified, each of which received strong bilateral support from the workshop delegates. Details of these research challenges are provided in this summary report. EPSRC and DST will seek to explore the opportunities provided by these challenges as the focus for a future jointly-supported bilateral research call between the two funding bodies.

This call, expected to commit up to £3 million (equating to up to Rs 23 crore) from both the UK and India, is expected in the 2012-2013 financial year. This call will be published on the EPSRC and DST websites in the coming months.

[1] For a full delegate list, see Appendix 1.
[2] For the full workshop agenda, see Appendix 2.

The Research Challenges

What follows are the outputs of the workshop discussions, presented in alphabetical order of their titles. Delegates were asked to structure their thoughts around a series of questions, as indicated in the summaries. At the conclusion of the discussions, delegates heard short presentations about the scope of each challenge, and then had the opportunity to indicate their personal preferences as to which challenge(s) had the most potential for joint UK-India research collaboration. Each challenge summary contains the tallied results of the preferences of the delegates.

Automation for Manufacturing

Key Research Questions

- Affordability and reliability.
- Modular and/or reconfigurable design.
- Adaptive/autonomous/smart automation.
- Dynamic modelling, kinematics and simulation of automation.
- Virtual prototyping for automation.

Relevant UK Strengths	Relevant Indian Strengths
• Capturing human skill. • Assessing the automation challenge. • Integrated automation solutions. • Validating automation systems.	• Human resource. • Capacity/capability of industry. • R&D base for development of sensor controller and models.
Pluses	**Opportunities**
• Cross-sectoral application. • Attractive domain to academia. • Replaces humans in debilitating processes. • Evolution of spin-off technologies.	• Multidisciplinary field. • Inevitable or essential for strategic applications. • Develop market leadership. • Development of small scale industry. • Rural/agricultural application.
Issues	**New Thinking**
• Global competition. • Environmental effects. • Trained manpower. • Acceptability. • Availability of matching materials.	• Novel use of new sensor technology, actuation devices and controllers. • Standard product platform. • Development of intelligent/autonomous machines. • Remote controlled factories. • Product sensing for adaptive control.

Total Votes		
36	UK	●●●●●●●●●●●
	India	●●●●●●●●●●●●●●●●●●●●●●●●

Engineering-Driven Sustainable Manufacturing

Key Research Questions

- How do we map, measure and monitor key sustainability dimensions?
- Compare, contrast and learn from sustainability drivers and strategies in different systems (*e.g.* industrial, geographic).
- Strategies, tools and technologies for resource efficiency and sustainability (*e.g.* sectoral vs. regional perspectives).
- Meeting specific environmental/sustainability targets?
- UK/India complementarity in the supply chain (*e.g.* sustainable manufacturing and resource-efficient manufacturing in SMEs, small vs. large batch manufacturing).

Relevant UK Strengths	Relevant Indian Strengths
• Lifecycle view of design & manufacture. • Catalysis expertise. • Long-term experience and maturity of field. • Integration of science and engineering expertise.	• Demands & needs of Indian industry provide world class aspirations, and appetite for technology. • Volume of manpower in manufacturing. • Emerging national policies can be influenced. • Distributed systems. • New build opportunity.
Pluses	**Opportunities**
• Protect the environment for future generations. • Complementary expertise between UK and India. • Learn from each other in industrial context. • Global collaboration with global applications.	• Wide ranging applicability. • New jobs in emerging market field. • New business opportunities.
Issues	**New Thinking**
• Different metrics applied in both countries. • Funding and investment from governments and industries. • Short-term increased cost. • Outcomes or results may not be applicable in both UK and India.	• Development of new sustainability metrics. • New design concepts. • Eco-efficiency in both UK and India.

Total Votes		
27	UK	●●●●●●●●●●●●●●●●●●●
	India	●●●●●●●●●

High Performance Materials and Processes

Key Research Questions

- Development of high performance composites for aeronautical or automotive structures, such as super alloys/emerging materials.
- Processing of multi-functional materials.
- Modelling of materials and simulation of manufacturing processes.
- Finding alternate materials and establishing sustainability.

Relevant UK Strengths / Relevant Indian Strengths

Delegates addressed these points in a single answer:

- Substantial know-how/knowledge base in material engineering in both Indian and UK organisations – "pooling-up" this expertise and supplementing with analytical skills of Indian researchers could open up new vistas.
- Strong past record and existing models of human resource/student exchange programs between India and the UK, especially at doctoral level.
- Multiple stake-holding agencies (industries/research labs/academia) from both UK and India are available for collaboration.

Pluses

- Cross-functional/multidisciplinary research area.
- Potential for substantial IP generation.
- Enhancement of performances (product and processes)/energy efficiency.
- The collaboration can serve both civil and strategic sectors of Indian and UK stakeholders.
- Multi-functional materials are of direct relevance to development of smart structures by Indian and UK organisations.

Opportunities

- Materials modelling, process modelling & optimisation, material characterisation.
- Development of systems with high strength-to-weight ratio, an aspect that is vital for automotive, aeronautical and bio-systems.
- Opportunity to create quick functional network among Indian groups (IITs/DRDO/CSIR/CMTI etc.) and UK groups (universities/aero industry/auto industry etc.).

Issues

- Process development of high performance materials is a broad topic with relevance to many user groups - focussing on a 'high-impact' 'novel' material processing is a must.
- Non-compatibility of the new materials/processes to distributed manufacturing model - it might entail major reinforcement or modification of existing infrastructure.
- Long lead time could be a concern.
- Scaling-up processes from micro-level to macro-level does not always work.

New Thinking

- Generation of near-net-shape products requires new materials and processes.
- Conventional processes are typically not equipped to handle new materials; hence this research area is an *ab initio* effort.
- Additive manufacturing/rapid prototyping of functional parts requires new materials.
- Major chunk of high performance materials are being imported by UK & Indian manufacturers - proposed research could bring in sustainability and involvement of domestic sector.

Total Votes		
42	UK	●●●●●●●●●●●●●●●●●●
	India	●●●●●●●●●●●●●●●●●●●●●●●●●●●●

Industrialisation of Biomedical Procedures

Key Research Questions

- Development of new biomedical materials.
- Cost effective scalability: from laboratories, to clinical trials, to volume production.
- Early stage evaluation of the whole process.
- Process capability and customisation.
- Supply chain efficiency and regulatory barriers.

Relevant UK Strengths	Relevant Indian Strengths
• Pharmaceuticals, including industry. • Biological (*e.g.* molecular stem cells). • Process and analytics (PAC and GMP). • Instrumentation. • Bioinformatics and modelling. • NHS and patient links.	• Pharmaceuticals. • Clinical trials → patient pool → cost. • Chemistry expertise.
Pluses	**Opportunities**
• Potential high impact on society and economy. • Core industry sector with growth potential. • Relevant to aging population. • Multidisciplinary frontier area of manufacturing. • Multiplying effort and progress. • Does “good for many”. • Strong alignment of expertise and need.	• Business and economic opportunities. • Growing world market. • Meets currently unmet needs. • Creates many new products. • Cross fertilisation of knowledge. • Huge healthcare/societal benefits.
Issues	**New Thinking**
• Regulatory requirements. • Cost-effective manufacture. • Long lead time for impact. • Infrastructure required for collaboration. • Interaction with clinicians vital. • Need 'informed' clinicians with strong ethical drivers.	• Necessitates a multidisciplinary approach. • Manufacturing-led innovation. • Life sciences with manufacturing. • Potential for holistic approach. • Mass production delivered on a personal basis.

Total Votes		
35	UK	●●●●●●●●●●●●●●●●●●●●●●●
	India	●●●●●●●●●●●●●●●

Integrated Materials Design, Modelling, Simulation and Verification in a Digital Platform

Key Research Questions

- Intra-operability among disciplines - domains, systems, languages.
- Integrity and quality of data.
- Representing domain capability.
- Optimising time and cost.
- Standards for cloud-based product-lifecycle management.
- Crowd-sourcing product development.
- Enablers for SMEs to move up the value chain.
- Focus on strategy and prototype and standards for a specific area.
- Mathematics for metrology.

Relevant UK Strengths	Relevant Indian Strengths
• Cost modelling • Simulation models form building blocks in specific areas (*e.g.* cost/quality modelling) • Mathematical modelling. • Process modelling.	• Software engineering. • Large variety of real-life data. • Multiple language skills.
Pluses	**Opportunities**
• Enables collaboration. • Scalability. • Reduces resources - time, cost, human. • Helps SMEs. • Multidisciplinary challenge. • Builds on the existing work in this area. • Complement the development of new materials (*i.e.* virtual validation).	• *Not articulated*.
Issues	**New Thinking**
• High potential investment required. • Convincing people to share experiences. • Large companies blocking new technology for SMEs?	• Develop capability based PLM. • Analytical/productive capability. • Integration of heterogeneous models. • Open platform development. • Solution oriented, through life.

Total Votes		
	UK	●●●●●●●●●●●●●●●●●●●●
36	India	●●●●●●●●●●●●●●●●●

Next-Generation Sensors for Manufacturing Processes

Key Research Questions

- What are the new adaptable sensor uses across sectors (*e.g.* high temperature, flows, scattering, material degradation)?
- What range of conditions and parameters can be measured accurately?
- Can we acquire large quantities of data across these processes more accurately?
- Can we mine and process the data to develop better algorithms and feedback centrally?
- Can these datasets produce quality impacts to materials and structures, knowledge management and design?

Relevant UK Strengths	Relevant Indian Strengths
• Sensor design. • Modelling and simulation. • Mathematical modelling. • Algorithm development.	• Data management. • Mathematical modelling.
Pluses	**Opportunities**
• Requires industrial and academic engagement. • Linking SMEs with large scale industries. • Need to take advantage of the range of new sensors emerging.	• Better input data to materials and structures, and new design thinking. • Cross-sectoral and 'multidisciplinary'. • Allows engagement across institutions. • Train students in essential skill sets for future growth. • Real-time measurements. • Calibration, traceability and standardisation.
Issues	**New Thinking**
• Managing the interfaces between disciplines and users. • Must link to materials and structures work effectively.	• Potential to upgrade existing assets to accommodate manufacturing plans and break through new processes. • Development of compact, fast, robust and reliable instrumentation and sensors.

Total Votes		
49	UK	●●●●●●●●●●●●●●●●●●●●●●●●●
	India	●●●●●●●●●●●●●●●●●●●●●●●●●

Realisation of Functional Surfaces

Key Research Questions

- Can we realise the "right" surfaces for the "right" applications through development of fundamental understanding of behaviour of surfaces and their degradation?
- What is the interplay between chemistry, microstructure and texture of engineered surfaces on their performance and failure?
- Can appropriate *in situ* monitoring techniques/"embedded sensors" be utilised to define manufacturing specifications?
- Can signature analysis of engineered surfaces be linked to manufacturing processes?
- How can one realise, characterise and measure reliably free-formed surfaces and coatings over large areas?
- Can the understanding realised by addressing the above questions be harnessed to generate surfaces "at will", as exemplified by (i) super-hydrophobic tribological coatings; (ii) "chameleon" coatings, whose functional attributes vary with environmental conditions; (iii) "stealth" coatings?

Relevant UK Strengths / Relevant Indian Strengths

Delegates addressed these points in a single answer:

- Centres of excellence exist in both UK and India, with experience/expertise in generation of engineered surfaces/coatings, their characterisation and performance evaluation.
- Available infrastructure spans all surface modification/engineering processes of current interest.

Pluses

- In most applications, a component surface is in contact with some other part or with the environment; hence, component performance and life are critically dependent on the functional to physical attributes of the surface.
- Realisation of an appropriate surface to combat all types of aggressive environments and operating conditions is the challenge; design issues are critical.
- Essential to understand the mechanisms responsible for tribological and/or functional behaviour of the surface and its degradation.
- Surface is often the signature of the process, thus suitable characterisation and measurement techniques need to be evolved three dimensions. Can these techniques be utilised for process control?
- Significant promise to device synergy through collaboration; islands of excellence in processing of surfaces, their characterisation and performance assessment available on both sides; process condition monitoring capability exists.

Opportunities

- Wide-ranging implications across diverse industry segments, therefore there are considerable cross-sectoral opportunities.
- Applications range from earth-moving (mining) to aerospace (astronomy) to bio-medical.
- Opportunity to:
  - enhance performance;
  - augment life;
  - reduce weight;
  - repair, refurbishment and overhaul.

Issues	New Thinking
• Surface compliance and its evaluation is application dependent. • Accelerated test protocols are elusive. • Uniformity in case of large-area coatings may be difficult; incorporation of *in situ* monitoring/sensors may be meaningful? • Integrated design incorporation of surface engineering as a front-end design strategy is important.	• Assess significance of interplay between chemistry, microstructure and texture on surface behaviour and its degradation. • *In situ* monitoring, characterisation and their utilisation to define manufacturing specifications. • Realisation and measurement of free-formed surfaces and coatings over large areas.

Total Votes	UK	●●●●●●●
36	India	●●●●●●●●●●●●●●●●●●●●●●●●●●●●●

Workshop delegates discuss shared research challenges between the UK and India.

Appendix 1: Workshop Participants

UK Delegates	
Mr. Stephen Burgess	Rolls-Royce
Professor Dariusz Ceglarek	Warwick Manufacturing Group
Dr. Michael Duncan	Procter & Gamble
Professor Sir Mike Gregory	University of Cambridge
Professor Alastair Florence	University of Strathclyde
Professor Richard Hague	Loughborough University
Dr. Ben Hicks	University of Bath
Dr. Graham Hillier	Centre for Process Innovation
Professor Mike Jackson	Loughborough University
Professor Jane Jiang	University of Huddersfield
Mr. Jeremy Lovell	Bombardier Transportation
Professor Gary Lye	University College London
Professor Derek McAuley	University of Nottingham
Mr. Mark Niziolomski	Jaguar Land Rover
Professor Kulwant Pawar	University of Nottingham
Dr. Kevin Potter	University of Bristol
Dr. Mark Purdie	AstraZeneca
Professor Shahin Rahimifard	Loughborough University
Professor Svetan Ratchev	University of Nottingham
Professor Rajkumar Roy	Cranfield University
Mr. Mark Summers	Airbus
Professor Nigel Titchener-Hooker	University College London
Mr. Mark Wilson	BAE Systems
Indian Delegates	
Dr V. Krishnamurthy	National Manufacturing Competitiveness Council
Dr Baldev Raj	President, Indian National Academy of Engineering
Mr. Ajay Bhatia	Larsen & Toubro
Dr. U. Chandrasekhar	Gas Turbine Research Establishment, DRDO
Dr. P. Girish	Confederation of Indian Industry
Professor S. Gowri	Anna University, Chennai
Professor B. Gurumoorty	Indian Institute of Science, Bangalore
Dr. Shrikant V. Joshi	International Advanced Research Centre for Power Metallurgy and New Materials
Professor V. Balasubramanian	Annamalai University
Mr Ved Prakash	Hi-Tech Industries, Gurgaon
Dr. K.P. Karunakaran	Indian Institute of Technology, Bombay
Mr. Madhukar V. Kotwal	Larsen & Toubro
Dr. B.R. Satyan	Central Manufacturing Technology Institute
Mr. Satish Kumar	Central Manufacturing Technology Institute
Mr. P.V. Shashi Kumar	Central Manufacturing Technology Institute
Dr. Sukul Lomash	Bharat Heavy Electricals Ltd.
Mr. G. Madhavulu	Bharat Heavy Electricals Ltd.
Professor Narinder K. Mehta	Indian Institute of Technology, Roorkee
Dr. Nagahanumaiah	Central Mechanical Engineering Research Institute
Dr. Prabir K. Pal	Bhabha Atomic Research Centre
Professor Soumitra Paul	Indian Institute of Technology, Kharagpur

Mr. Anil V. Parab	Larsen & Toubro
Dr. Jayant Patil	Larsen & Toubro
Professor P. Radhakrishnan	PSG Institute of Advanced Studies, Coimbatore
Professor V. Radhakrishnan	Indian Institute of Space Science and Technology
Mr. Prabhat Ranjan	Bhabha Atomic Research Centre
Professor B. Ravi	Indian Institute of Technology, Powai
Dr. Y. Ravikumar	National Institute of Technology, Warangal
Professor N. Venkata Reddy	Indian Institute of Technology, Kanpur
Professor S.K. Saha	Indian Institute of Technology, Delhi
Mr. Supriya Sarkar	Sandvik Asia PVT Ltd.
Professor M.S. Shanmugham	Indian Institute of Technology, Madras
Professor Manoj K. Tiwari	Indian Institute of Technology, Kharagpur
Dr. B. Venkataraman	Indira Gandhi Centre for Atomic Research
Dr. S. Venugopal	Indira Gandhi Centre for Atomic Research
Dr. P. Chellapandi	Indira Gandhi Centre for Atomic Research
Dr. B. Vinod	PSG College of Technology, Peelamedu
Engineering and Physical Sciences Research Council Delegates	
Dr. Mark Claydon-Smith	EPSRC
Dr. Derek Gillespie	EPSRC
RCUK India Delegates	
Dr. Helen Bailey	RCUK India
Dr. Alicia Greated	RCUK India
Ms. Sukanya Kumar-Sinha	RCUK India
Ms. Shalini Singh	RCUK India
UK Science & Innovation Network Delegates	
Mr. Kinchit Bihani	Science & Innovation Network India
Ms. Catherine Brain	Science & Innovation Network India
Ms. Swati Saxena	Science & Innovation Network India
Mr. Mark Sinclair	Science & Innovation Network India
Department of Science and Technology Delegates	
Dr. T. Ramasami	Secretary, DST
Dr. A. Mukhopadhyay	DST
Er. Milind Kulkarni	DST
Other Delegates	
Mr. Sanmit Ahuja	ETI Dynamics
Ms. Nancy Pignataro	Intellectual Property Office, UK
Ms. Christine Reid	Northwood Reid, Oxford
Mr. James Bevan	British High Commissioner to India

Appendix 2: Workshop Agenda

Monday 30 January 2012	
09:00 – 09:10	**Welcome** Mr. James Bevan, British High Commissioner in India Dr. T. Ramasami, Secretary, Department of Science and Technology
09:10 – 09:20	**Keynote Address** Dr. V. Krishnamurthy Chairman, National Manufacturing Competitiveness Council
09:20 – 09:50	**The UK/India Manufacturing Landscape: Background and Context** Dr. Mark Claydon-Smith, EPSRC Professor Sir Mike Gregory, Cambridge Institute for Manufacturing Dr. Baldev Raj, President, Indian Academy of Engineering
09:50 – 10:45	**Research Themes in Advanced Manufacturing in the UK and India** *Moderated by Madhukar Kotwal, President, Larsen and Toubro* Professor Richard Hague, Loughborough University Prof V. Radhakrishnan, Indian Institute for Space Science and Technology
11:15 – 12:00	**Research Themes in Advanced Manufacturing in the UK and India** Professor Nigel Titchener-Hooker, University College London Professor B. Ravi, Indian Institute of Technology Bombay
12:00 – 13:00	**Structured Networking** • *What are the manufacturing research challenges to be discussed?* • *What are the strengths and research needs of UK and Indian manufacturing research?*
14:00 – 15:00	**Ideas Exchange** • *What are the strengths and research needs of Indian and UK manufacturing research?* • *What are the top five research themes for UK-India collaborative research?*
15:30 – 17:30	**Developing the Ideas Further** • *What are the key research questions in this research area?* • *What are the UK and Indian strengths in this area?* • *What are the benefits of further collaboration this area?* • *What opportunities might be created by this idea?* • *What concerns are they in this area?* • *How does this research advance state of the art?*
17:30 – 18:30	**Review and Contribution to Emerging Themes**

Tuesday 31 January 2012	
09:00 – 10:00	**Feedback on Day One** *Presentation summaries of developed research challenges.*
10:00 – 10:30	**Delegate Preferences** *Expressions of interest in developed research challenges.*
10:40 – 11:10	**Models for collaboration between the UK and India** High Value Manufacturing Catapult Centre: Dr. Graham Hillier, Centre for Process Industries WMG-IIT Kharagpur Collaborations: Professor Darek Ceglarek, Warwick Manufacturing Group, and Professor Manoj Tiwari, Indian Institute of Technology Kharagpur

11:40 – 12:25	**Intellectual Property Management in cross-border collaboration between the UK and India** Ms. Nancy Pignataro, Intellectual Property Office Ms Christine Reid, Northwood Reid Dr A.S. Rao, IIM Ahmedabad
12:25 – 12:45	**Summary and Feedback** Dr. Mark Claydon-Smith, EPSRC Dr. T. Ramasami, Secretary, Department of Science and Technology
13:30 – 14:45	**UK-India panel discussion: the systematic problems, the drivers that cross link academia – industry and how research can be taken out into the real world** Led by Mr. Sanmit Ahuja, ETI Dynamics, with: o Professor Sir Mike Gregory, Cambridge University o Professor Rajkumar Roy, Cranfield University o Mr. Mark Nizolomski, Jaguar Landrover o Dr. Baldev Raj, President, Indian Academy of Engineering o Professor B. Ravi, Mechanical Engineering, IIT Bombay o Mr. Anil Parab, Larsen & Toubro
14:45 – 15:15	**Closing Remarks**
Wednesday 1 February 2012	
09:00 – 14:00	**Site Visit to Larsen & Toubro** Tour of L&T facilities in Mumbai, and panel discussion with senior L&T staff

Delegates are taken through the next steps of the workshop by Dr. Derek Gillespie, EPSRC.

Participants and organisers of the UK-India workshop on Advanced Manufacturing research challenges.

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Advanced Manufacturing Research Challenges

Report compiled by:

Dr. Derek Gillespie

EPSRC Portfolio Manager

Manufacturing the Future Theme

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