Economic Impact of the Innovative Manufacturing Research Centres:

Final Report

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10th May 2011

Acknowledgements:

DTZ and EPSRC would like to thank the 100 or more IMRC staff, industrial collaborators and other stakeholders who were consulted as part of this study. Your contributions have been extremely valuable, and have provided DTZ with a rich evidence base on which to undertake this assessment.

DTZ would also like to thank the steering group consisting of EPSRC and IMRC staff for their inputs into the study.

Contents

Abbreviations

AWM	Advantage West Midlands
BIS	The Department of Business, Innovation and Skills
BSI	British Standards Institute
EMDA	East Midlands Development Agency
EMP	Engineering for Manufacturing Programme
EPSRC	Engineering and Physical Sciences Research Council
FIDIC	International Federation of Consulting Engineers
FTE	Full-time equivalent
GVA	Gross Value Added
HEI	Higher Education Institution
IMRC	Innovative Manufacturing Research Centre
IP	Intellectual Property
ISO	International Standards Organisation
KTP	Knowledge Transfer Partnership
KTS	Knowledge Transfer Secondment
MOD	Ministry of Defence
NHS	National Health Service
OFT	Office of Fair Trading
PDR	Post-Doctoral Researcher
R&D	Research and Development
SME	Small to Medium-sized Enterprise
SRIF	Science Research Investment Fund
TSB	Technology Strategy Board
UAV	Unmanned Air Vehicle
UKTI	UK Trade and Investment

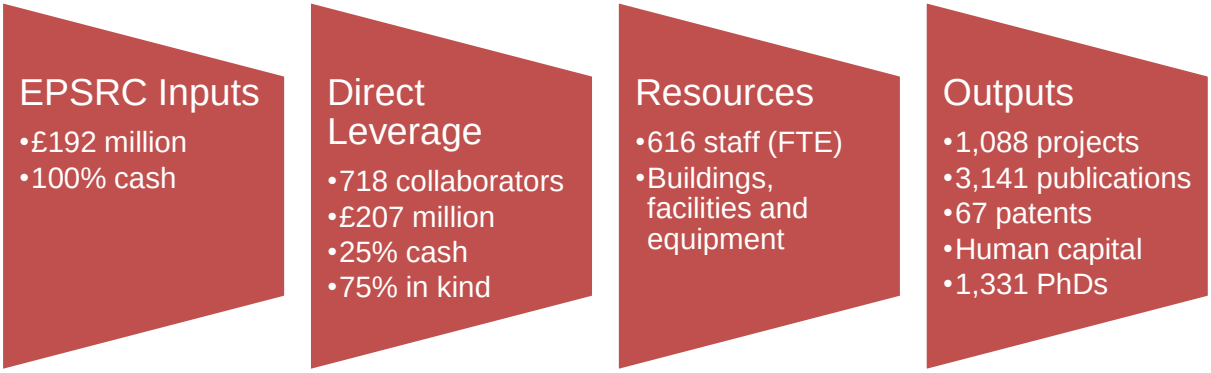
List of IMRCs covered by this review:

- Bath Innovative Design and Manufacturing Research Centre (Bath IdMRC)
- Cambridge Engineering Design Centre (Cambridge EDC)
- Cambridge Institute for Manufacturing (Cambridge IfM IMRC)
- Cranfield Innovative Manufacturing Research Centre
- Health and Care Infrastructure Research and Innovation Centre (HACRIC)
- Heriot-Watt Innovative Manufacturing Research Centre (HW-IMRC)
- Imperial Innovation Studies Centre
- Innovative Electronics Manufacturing Research Centre (IeMRC)
- Loughborough Innovative Manufacturing and Construction Research Centre (Loughborough IMCRC)
- Multidisciplinary Assessment of Technology Centre for Healthcare (MATCH)
- Nottingham Innovative Manufacturing Research Centre
- Reading Innovative Construction Research Centre (Reading ICRC)
- Salford Centre for Research and Innovation in the Built and Human Environment
- University College London Bioprocessing Centre
- Warwick Innovative Manufacturing Research Centre

Executive Summary

Manufacturing is one of the key sectors of the UK economy – employing 2.6 million people and accounting for 11% of GDP. Research activity has become crucial to maintaining competitive edge, and the UK compares well against the leading industrialised nations in terms of the level of R&D.

The Innovative Manufacturing Research Centres (IMRCs) were established in 2001 to provide a focus for EPSRC investment in innovative manufacturing. The **total investment in the IMRCs by EPSRC was £192 million**, which has directly leveraged a further **£207 million of contributions** from the **718 collaborators** involved in one or more of the IMRCs.



DTZ was commissioned by EPSRC to assess the economic impact of the IMRCs. General performance data were collected across all 15 IMRCs while more detailed reviews of 8 IMRCs led to **32 case studies** of impact, accounting for **£17.9 million of EPSRC funding**, or 9% of total EPSRC funding for IMRCs. Impacts are summarised in the following table according to BIS impact categories:

Gross Impacts - Case study level (32 case studies, or 9% of the IMRCs programme)	
Improving Existing Businesses • Creating 160 new jobs • Safeguarding 230 jobs • £70m additional sales to date • Growth in market share • 20 technologies/ products to market • Licensing fees of £43m • Cost savings £10m p.a. • Safeguarding several businesses • Increasing capacity, productivity, business planning, networking between companies	**Benefits to Public Policy & Services** • Influencing public sector investment • Informing public sector policy/ strategy (OFT, UKTI etc) • Informing new standards (ISO, FIDIC, BSI) • Potential cost savings to the public sector of £17m+ p.a. (NHS, MOD)
Creating New Businesses • 8 spinouts in the UK • 11 spinouts overseas – due to 'open source' nature of research	**Other** • Environmental benefits - reduced emissions and waste to landfill
Generating Human Capital • 50% of former staff/students recruited into industry • Co-supervision of PhDs / EngDs by industry • Successful Knowledge Transfer Partnerships and Knowledge Transfer Secondments	**Leveraging Investment** • Direct leverage of £0.80 - £1 for every £1 invested by EPSRC • Total leverage of £12.75m for the 32 case studies • Confirmed follow-on funding of £39m across the 32 case studies

Gross Impacts - IMRC-Level (for all 15 IMRCs as a whole)
• 616 FTE current staff. The IMRCs have invested heavily in new permanent staff. • Trained 1,331 PhD students, which corresponds to an estimated uplift in lifetime earnings of £262million. • Contributions to academic and industry training with enrichment of student experience • Leverage of £207m of cash and in-kind contributions across all IMRCs • Significant income from overseas students • Capacity building - investment in equipment and buildings • Inward investment supported directly and indirectly – for example investment of £5m+ by Boeing and partners into an Integrated Vehicle Health Management Centre associated with Cranfield IMRC; and Tata Motors investing £85m to date in a European Technical Centre based on the University of Warwick campus, building on the collaboration with Warwick Manufacturing Group. • Development of new networks and relationships • Secondments with other institutions and industry
Conversion of Gross Impacts to Net Impacts
• **Leakage:** generally low as the IMRCs have tended to work with collaborators with a UK presence • **Displacement**: low, as IMRC research is generally at an early stage where there are market failures which prevent companies from investing in their own right. • **Substitution and Crowding Out:** not deemed to be relevant to the investment in IMRCs. • **Attribution:** selected case studies have shown that between 20% and 50% of the impact can be attributed to the work of the IMRCs, with the remainder attributable to pre-IMRC work, and the involvement of collaborators and other parties/funders.

Analysis on return on investment shows that for the 32 case studies considered, the actual gross impact to date is around **16 times the EPSRC investment**. Once additionality and the mix of projects within the case studies are taken into account the **net impact has been calculated as between 5 and 13 times the EPSRC investment**.

As well as the significant actual impacts to date, future impacts could be even greater. The IMRCs have only had a limited time to develop. Whilst some have been funded for 10 years, many only consolidated and focused their research strategies from 2006 onwards. It also takes time to build industrial partnerships – but these are now extremely well developed. Given that many basic research projects can take 10-20 years to deliver actual impacts, we would expect even greater impacts to develop from current research over the next 5-10 years.

Added Value of the IMRCs

This study has identified a number of added value features of the IMRC model. It is the **combination of all of these features** which delivers the added value of the IMRC model.

IMRC feature	Added value
Continuity of funding	• Building critical mass and capacity in terms of staff and industry links • Supporting a portfolio of both fundamental and applied research • Providing sufficient time and resources for research ideas to be developed fully • Benefits in terms of development of staff
Strategic approach to research	• Clear long term vision • Relevance to industry • Targeted investment in resources (buildings, equipment and staff)

IMRC feature	Added value
Industry focus	• Industry linkages (university to industry and industry to industry) • Building long term, deep relationships • Widening exposure to new companies and sectors • Leveraging funding, inward investment and industry resources e.g. Data, equipment, IP • Enrichment of staff and student experience with economic benefit
Multi-disciplinary and cross institutional	• Creating novel solutions to problems • Knowledge exchange (between departments, institutions and with industry) • Creating critical mass and sharing resources • Developing deep relationships • Developing and raising the profile of host departments
Local governance and management	• Relevance to industry through steering group composition • Speed of response to funding requests • Further enhancing industrial linkages • Ability to take calculated risks with local knowledge
International peer review	• Validation of research quality as internationally competitive • Ability to refine and change direction

The added value of the IMRCs is demonstrated through the following selection of quotes from industrial collaborators:

"*Without the responsiveness of IMRC model, we could not have built up this strategic academic-commercial relationship with Heriot-Watt University. We would have had to resort to the 'old model', based on short, focused, small pieces of work. Renishaw's contribution would have been less and the returns would have been modest. We would have been scratching the surface rather than achieving a major impact in 5 years time."* **Research and Development Manager, Renishaw**

"The research project created a trusted network of companies with people sharing not only explicit, but tacit information that would not normally have been disclosed..... it has given all the companies involved a new insight into costing techniques that can be used to grow the UK's share of the global defence market." **Phil Wardle, Business Improvement Manager at BAE Systems**

"*There is no way we could have developed this technology ourselves. The IMRC project represented an ideal opportunity to work together. We do not have the knowledge and expertise to develop new materials but it is one of the ways in which we can innovate and develop our products. Cranfield IMRC had a new material but no route to take it to market. This project was a golden opportunity to work together and we certainly intend to continue this relationship*." **Chris Gerrard, R&D Manager at Westwind Air Bearing Spindles**

"*We made a real breakthrough at NPL in coming up with a completely different type of probe design, but we needed help to turn it into a practical device. The specialist knowledge and skills at the IMRCs and other universities helped us to turn the research into a practical device which is in the process of being commercialised*" **Professor Richard Leach, NPL**

"The underlying principle of the Knowledge Information Management Project – providing the right information in the right context at the right time – is at the heart of our business proposition. In addition to the enormously useful insights gained into the information management problems that we face every day, engagement in the KIM Project and its knowledge transfer activities has proved very useful in developing our Group Knowledge Management Strategy. The outputs of the research have been useful in bringing together silos of knowledge and information – both within Balfour Beatty itself, and between the firm and academia." **Simon Flint, Business Development Manager, Balfour Beatty**

Best practice lessons which can be learned through the investment in the IMRCs are:

- The IMRCs have achieved **very high levels of industry engagement**, through strategic input from industry into research strategy and collaboration on individual projects. This has resulted in the IMRCs pursuing industry-relevant research, with significant investment of resources by industry. The IMRCs have developed deep relationships with industry, and broadened their exposure to a wider set of businesses and sectors than previously.
- The **continuity of funding** has given certainty to the IMRCs and industrial collaborators, and allowed the IMRCs to make strategic investments in human resources, buildings and equipment. This is a step-change from the previous Engineering for Manufacturing Programme, where research centres were spending a disproportionate amount of time working on funding proposals rather than research.
- Related to this, the IMRCs have been far more **strategic in their approach to research** than in alternative funding models; with a clearly defined vision and research goals. Given that the research strategies have been informed by industrial stakeholders, this ensures the relevance of the research. This has been further supported by the **International Peer Review** process – which involved a review of each of the IMRCs by leading UK and international experts and international benchmarking of IMRC research. This has been a key mechanism to focus the IMRCs on **high-quality and internationally leading research**. All of these mechanisms are support by the strong governance and management systems and practices within the IMRCs.
- The devolution of decision-making to the IMRCs has allowed them to be far more **responsive to industry**; and able to take **calculated risks** on emerging research ideas where appropriate – which has led to demonstrable economic impacts already.

Looking forward, a number of IMRCs are already considering the next steps for their research. It is clear that the IMRC programme has resulted in strong industrial networks and collaborations, and innovative projects; but that **further time and investment** may be required in order to fully maximise the impact.

The scale of EPSRC investment is significant but when compared to the annual R&D budgets of some of the industrial partners is actually quite small. It is likely that the scale of impacts identified in this impact assessment is conservative, and further significant impacts will emerge from the IMRCs in the coming years.

1. Introduction

DTZ was commissioned by the Engineering and Physical Sciences Research Council (EPSRC) to undertake an assessment of the economic impact of EPSRC's investment in the Innovative Manufacturing Research Centres (IMRCs).

The aim of the study, as set out in the invitation to tender, is to *'assess the economic impact, value and use of the research carried out by the IMRCs to the industrial, commercial and public sector collaborators and to the UK economy as a whole and to understand the route by which that impact is achieved.'*

The IMRCs were set up in 2001 to provide a focus for EPSRC investment in innovative manufacturing. Hosted at leading UK universities, 17 IMRCs were funded in total with 15 in existence at the time of review[1]. IMRCs were to collaborate closely with industry to deliver solutions to manufacturing challenges and deliver measurable impacts on the UK economy.

The specific objectives of DTZ's work were:

- To produce a report that illustrates and quantifies the impact of the IMRCs
- To understand the added value that IMRCs give in comparison to individual project grants
- To make recommendations on how EPSRC might maximise the impact of research in future
- To support development of appropriate impact assessment methodologies for new Centres to use themselves
- The scope of the review was limited to the 15 current IMRCs (two previously funded IMRCs were not included) with 8 IMRCs selected for more detailed impact assessments.

This overview report contains a summary of key highlights, lessons learned and recommendations for the future. In addition, there are 8 more detailed reports on individual IMRCs which form the evidence base for this overview report.

The remainder of this report is structured as follows:

- Section 2 sets out the methodology for the work
- Section 3 provides an overview of the IMRCs and their history
- Section 4 reports the findings on economic impact
- Section 5 discusses the different pathways to impact uncovered by the research
- Section 6 highlights the added value of the IMRC model
- Section 7 sets out our conclusions and recommendations.

[1] See http://www.epsrc.ac.uk/research/centres/currentimrcs/Pages/default.aspx for a full list of IMRCs.

2. Methodology

A detailed methodology for the review was developed by DTZ to meet the stated objectives. The key features of the methodology are set out below. This methodology consisted of a number of stages as follows:

- Review of annual reports across all IMRCs
- Consultation with EPSRC staff responsible for IMRCs
- Development of a basis for selection of IMRCs for more detailed review
- Development of an impact assessment framework and key data for review
- Consultation across IMRCs and collaborators to gather the evidence
- Impact modelling
- Verification of the findings with IMRCs and collaborators
- Development of the evidence to provide the overview report and its conclusions.

Budgetary and time constraints meant it was not possible to review all 15 current IMRCs in detail. While general performance data were collected across all 15, 8 IMRCs were selected for more detailed review on the basis of research themes and sector coverage. The basis for selection, which took place in consultation with the steering group, is set out in Figure 2.1:

Figure 2.1: Final selection of IMRCs for more detailed review

Sector	Selected IMRCs
Aerospace	Cranfield
Automotive	Warwick
Pharmaceutical	UCL
Construction	Reading & Loughborough IMCRC
Healthcare	Warwick
ICT/Electronics	Heriot Watt
Generic / cross sectoral	Cranfield & Loughborough IMCRC
Research Theme	
Design process (min 2 IMRC selected)	Bath, Cranfield, Loughborough
Technology	All selected IMRCs except Reading
Management (min 2 IMRCs selected)	Cambridge IFM, Reading, Loughborough

The final selection above provides coverage of sectors, research themes, types of activity undertaken and a sufficiently large number of impact case studies. It also provides good coverage of types of research outputs, IMRC size (by funding and number of projects), identified best practice, and geographical/institutional coverage.

To assess the impact of the IMRCs, an assessment framework was developed as set out in Figure 2.2. Through the desk research and a consultation programme, DTZ drew out relevant information relating to inputs (funding, leverage and resources), outputs, pathways and impacts. In total, DTZ consulted with 96 individuals, including researchers, collaborators, government stakeholders and policymakers.

Figure 2.2: Economic Impact Assessment Framework

Impacts were then modelled by drawing upon available market, government and industry data. Impact findings were verified with IMRCs and collaborators.

There were limitations to the study given the resources available, which need to be borne in mind when using the information generated through this study:

- **Basis of the work** – the study was not an evaluation or independent review of research. Therefore it did not seek to assess research quality or efficiency. It was focused on assessment of actual and potential impacts of research projects.
- **Selection of case studies for impact** – existing case studies were drawn from IMRC annual reports and consultation with IMRC Centre Directors. IMRCs were asked to provide case studies which best demonstrated their areas of research, and the typical impacts resulting. Whilst this introduces bias in selection, DTZ was able to test and verify the resulting impacts.
- **Views on added value of IMRC model** – a key part of the work was to collect views on the added value of the IMRC model. Clearly researchers and collaborators have a vested interest in the IMRC model. DTZ therefore used its wider experience in assessing research programmes to provide an objective view of the benefits.
- **Impacts** – the impact assessment can only provide a snapshot as new impacts are emerging all the time. The impacts, therefore, can generally be taken to be conservative.
- **Evidence base** – the founding principle for the study has been to develop a sound evidence base from which to draw conclusions on impact, added value and lessons learned. Where there is weak or limited evidence, this is highlighted in the text. In some cases, additional case studies have been researched but not reported due to a lack of evidence.
- **Grossing up** – given the wide number of case study and impact types, grossing up of the results is not possible. However, general assumptions around impact and return on investment can be made from individual case studies or groups of similar impacts.

3. IMRC Context and Overview

3.1 UK Manufacturing Sector Context

In 2009, manufacturing was the third largest sector in the UK economy at 11% of GDP and employing 2.6 million people (8% of the UK workforce)[2]. At the global level a number of trends are apparent in the manufacturing sector including:

- **Globalisation** leading to intensified competition (including with emerging economies)
- **Offshoring** of lower value manufacturing activities
- **'Servitization'** of manufacturing – a marked growth in the bundling of services with complex manufactured products. As an indication of the level of servitisation in the manufacturing sector, it is revealing to note that 14% of UK service exports related to manufacturing in 2009
- **Changes in demand** – due to the growth in global populations, the requirement for greener products, technological progress, and rapid growth in emerging markets.

Ongoing trends in the UK Manufacturing Sector include the following:

- High levels of innovation and investment in skills and knowledge
- Specialisation in higher-technology industries – such as aerospace and pharmaceuticals
- Research activity has become crucial to maintaining competitive edge – the UK compares well against the leading industrialised nations in terms of the level of R&D
- The proportion of UK manufacturing firms exporting is increasing

3.2 Market Failure and Rationale for Investment

Overall, the UK Manufacturing sector is well placed to respond to these changes. However, there are a number of **market failures** which may hold back investment in innovation and industry. Figure 3.1 describes these market failures, and how government interventions such as the investment in the IMRCs could potentially help to overcome them:

Figure 3.1: Market Failure

Market Failures	Rationale for IMRC model
Risk aversion There is a market failure in the allocation of investment to R&D activities due to the uncertainty of successful outcomes, and risk aversion within firms. In many cases, research challenges can be so large and complex that they are beyond the resources of individual companies.	The IMRC model is able to share risk between the public sector and industry, and between collaborators. It encourages investment in tackling major challenges.

[2] BIS (2010) Manufacturing in the UK: An Economic Analysis of the Sector

Market Failures	Rationale for IMRC model
Information and collaboration failures Related to the above, companies are unlikely to form the necessary collaborations to address significant research challenges. There is an important collaboration role of the public sector to bring companies with similar research needs together. The knowledge exchange between researchers within and between departments and institutions, companies, and other stakeholders is extremely important in overcoming this market failure.	The creation of the IMRCs with appropriate governance and management systems and funding has ensured that key information and collaboration failures are addressed.
Externalities and Knowledge-spillovers Many research projects provide benefits at an industry-wide level which could not be captured by one company alone. Knowledge generated by one firm often diffuses into the industry as a whole through partnership working or through movement of human capital. Therefore individual firms are unable to capture the full benefits of research, and may therefore make a sub-optimal level of investment in research.	Public sector investment ensures benefits are made available widely to support sectors or are licensed through appropriate agreements.

3.3 Overview of the IMRCs

History

The IMRCs programme replaced the preceding Innovative Manufacturing Initiative (IMI), which was funded under EPSRC's Engineering for Manufacturing Programme (EMP). The IMI was an industry-led, sector-focused programme of research funding, designed to encourage collaboration between industrial and academic partners. It ran from 1994 until 2001, in which time it provided £60 million of EPSRC funding to 350 individual research projects across the Aerospace, Land Transport, Construction, Process, and Healthcare sectors. One of the differences between the IMI and the IMRCs programme is the number of institutions involved, and extent of concentration of funding. Under the IMI, research funding was spread across 75 institutions (more than 150 university departments), and around 400 industrial collaborators.

The decision was taken to create the network of IMRCs in 2001, to consolidate the support which key institutions had been receiving under the IMI. **Eleven IMRCs were created initially** (in 2001/02) plus a further five in 2003/04, bringing the total to 16 IMRCs – each with **initial funding for five years**. The majority of IMRCs were extended for an **additional five years** from 2006 onwards. The IMRCs at Liverpool and Cardiff were discontinued at this point; whilst HACRIC (Health and Care Infrastructure Research and Innovation Centre) was established. Current IMRC funding will come to an end over the period 2011-15.

The creation of the IMRCs was a significant change in the way manufacturing research was funded, with a much greater concentration of funding into a smaller number of institutions and centres – i.e. 15 IMRCs compared to the 75 institutions involved in the IMI. Around 75% of the funding under the IMI was already concentrated within 20 HEIs, with this elite group consistently achieving a significant share of IMI funding.

Another difference between the IMI and IMRCs is the method of allocating funding. The IMRCs were allocated funding for a five-year period; whereas under the IMI, institutions had to bid for funding. On average under the IMI mode, it took three proposals and an indeterminate number of outlines to secure each new grant. Under the IMI, institutions also had to be aware of an array of calls, schemes and funding opportunities, which together with the time taken to write proposals detracted from the time available to do the research. Under the IMRCs programme, a decision was made to shift towards

providing consolidated funding to selected major groups over longer time frames together with a commensurate increase in resources devoted to evaluation of achievement, management, and dissemination and knowledge transfer.

What Defines an IMRC?

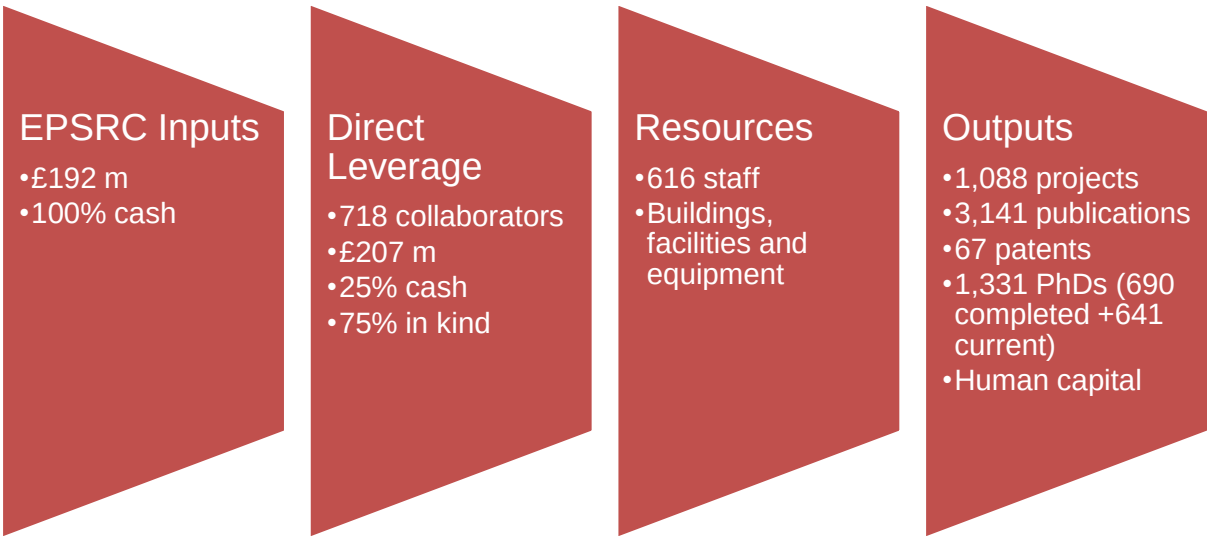
The objectives of the IMRCs as defined under the Innovative Manufacturing Programme are:

- To create, deliver, disseminate and exploit a coherent programme of novel research in innovative manufacturing.
- To focus on the integration of engineering and management science to deliver novel, competitive and relevant research outputs.
- To generate significant world-class new knowledge and provide strong support to the UK manufacturing sector, in its broadest sense
- To strengthen and expand strategic partnerships between the centres, other research groups, industry and other collaborators
- To provide greater focus on outputs, their impact on wealth creation and on society, and to improve technology transfer

Key Metrics

The following Figure provides a summary of key metrics relating to the IMRCs:

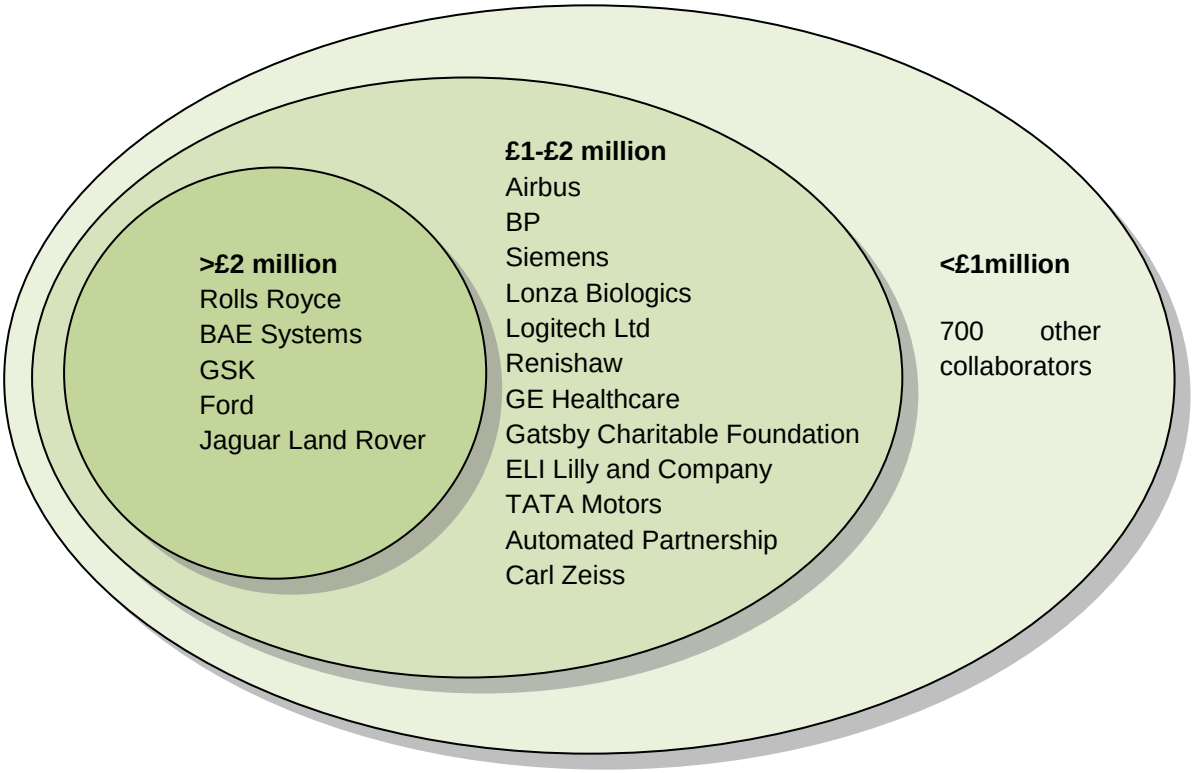
Figure 3.2: IMRC Key Metrics



EPSRC has made a significant investment of just over **£192 million** into the IMRCs (this includes actual and committed expenditure within the current phase of the IMRCs). This investment has directly leveraged a significant amount of additional funding – a further **£207 million of contributions** from the **718 collaborators** involved in one or more of the IMRCs. This equates to a leverage of an additional **£1.08 for every £1 invested by EPSRC**. Of this leveraged investment, 25% is cash whilst the remaining 75% has come in the form of benefits in kind, including the provision of human resources, data, and equipment.

Key collaborators across the IMRCs as a whole are summarised in the following Figure. Seventeen collaborators have provided more than £1 million each in cash or in-kind contributions. The average contribution per collaborator was £118,000 (median = £30,000).

Figure 3.3: Key Collaborators across all IMRCs (by cash and in-kind contributions to date)



Overall, the investment in the IMRCs is directly supporting **616 staff at present** (including academics, researchers, and administrative staff). A total of **1,331 PhD students** have been involved with or supported by IMRC funding (including 690 completed to date, plus a further 641 ongoing). The investment by EPSRC has also supported investment in buildings, facilities and equipment within the IMRC host institutions. Indeed, many of the IMRC host institutions have made additional investment beyond the direct IMRC funding through other funding routes such as SRIF.

The IMRCs have undertaken and/or funded a total of **1,088 projects to date**, some of which involve more than one IMRC. Outputs from the IMRCs as a group include over **3,100 publications, and 67 patents.**

Research Strategy and Structure

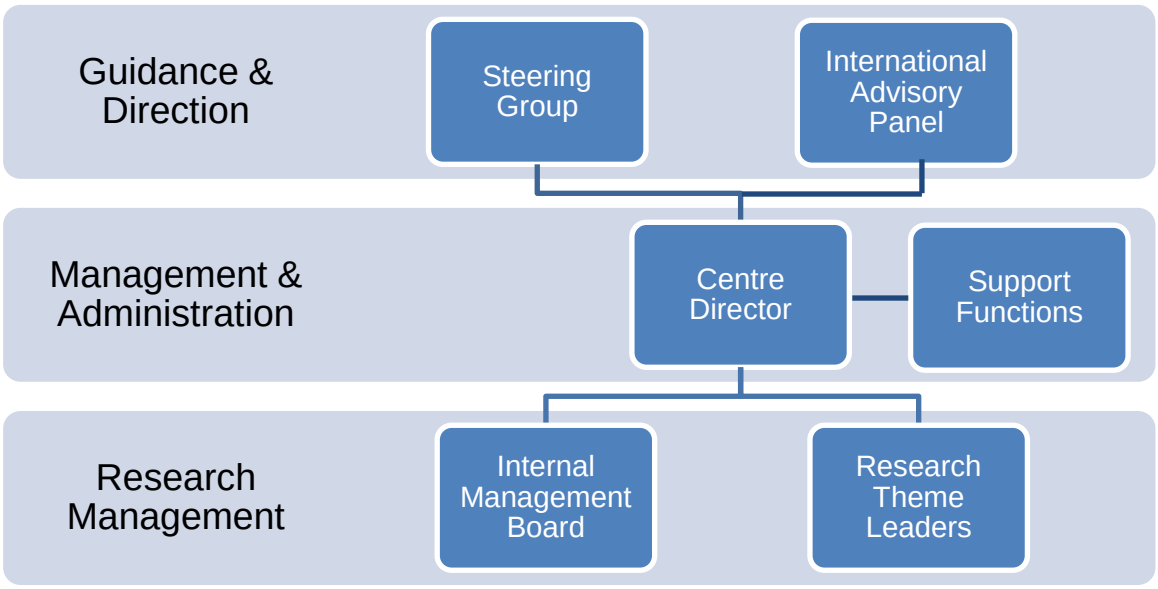
Most IMRCs started out with a number of **legacy projects** from grants under the EPSRC Innovative Manufacturing Initiative (IMI), which formed the basis for a number of research themes. EPSRC completed a series of **international reviews** during the first Phase of the IMRCs. In most cases, the reviews concluded that the research strategies of the IMRCs **could be more coherent**. The reviews were extremely valuable in guiding IMRCs towards the most valuable areas of research, often resulting in the IMRCs **refocusing and consolidating** the research themes moving into Phase 2. In some cases, there was a **shift in focus between Phase 1 and Phase 2** – for example in the case of Cranfield there was a greater emphasis on basic research in Phase 2.

There is a degree of commonality in the management structure of the IMRCs, with a typical structure as follows:

- An **Executive Steering Committee** provides input on policy and strategic direction. This is comprised by representatives from industry and the international research community.

- An International Advisory Panel provides input on research themes and output quality to ensure that the work of the centre remains internationally-leading. The panel is comprised of UK and international academic and industrial experts.
- The Centre is typically managed by a **Centre Director**, together with support functions.
- The Centre Director is supported by Research Theme Leaders, who usually also sits on an **Internal Management Board.** The Internal Management Board takes responsibility for operational issues and is responsible for the prioritisation of research within the centre.

Figure 3.4: Structure of a Typical IMRC



Overview of Grand Challenges

EPSRC has funded four 'Grand Challenge' projects primarily involving IMRCs together with a number of non-IMRC university departments. The Grand Challenge concept is to fund ambitious research programmes which are far greater than can be achieved through a single research grant or research institution. The criteria for 'Grand Challenge' research projects are:

- Potential for internationally leading research
- Potential to create a step change in current knowledge
- Potential for a positive societal and/or economic impact
- Focuses on long-term goals
- Potential to build on UK research capacity
- Potential for adopting a multi-disciplinary approach

The four Grand Challenges involving IMRCs can be summarised as follows. The first three of these have been discussed in detail within the impact case studies in Section 4.

Figure 3.5: Overview of the Four Grand Challenges

3-D Mintegration (abbreviation for 3D Miniaturised/ Integration)	KIM Grand Challenge Project (Through-Life Knowledge Information Management)
4 IMRCs plus 3 other research centres 4.5 years duration with £4.2m funding Aims to revolutionise the way that small micro / nano products and components are manufactured	8 IMRC's plus 5 other departments from 11 different UK Universities £5.5million funding The purpose of the project was to establish good practice for the design and use of information and knowledge-support systems.
Regenerative Medicine (ReMedi) Grand Challenge	**Innovation and Productivity Grand Challenge**
4 IMRCs and a number of other collaborators 4-year programme, £4.2 million EPSRC funding Sought to demonstrate how established bioscience could be transformed into profitable commercial practice and generate affordable therapies.	5 IMRCs involved, £1.6 million, 3 years Explores the implications of the changing 21st century context of networked, global and increasingly open innovation – a world in which knowledge flows become as important as knowledge creation

4. Economic Impact

As described in Section 2 above, DTZ reviewed 8 of the 15 IMRCs in more detail.[3] This involved an assessment of the whole IMRC, its structure, governance, added value and 3-6 impact case studies (either individual projects or clusters of similar projects). In total, 32 impact case studies were completed. This section draws together the findings in terms of the economic impacts identified from the case studies.

The 32 case studies can be summarised as follows:

- The case studies account for around 9% of total EPSRC funding for IMRCs to date (**£17.95 million)**
- The average project size (EPSRC funding) is £561k (median £267k, range £30k - £4.2m)
- The projects resulted in **£12.75 million** of known leverage (cash and in kind contributions), although for 9 case studies the leverage was unknown.
- For those where the level of leverage is known, this equated to an average leverage of £554k per project, or **70-80p per £1 of EPSRC funding**
- Three Grand Challenge projects were included in the case studies. These are much larger than the others - accounting for £9.8million of EPSRC funding (or 55% of the total EPSRC funding across all 32 case studies). The level of leverage for the Grand Challenges is comparatively lower than other projects, with a leverage of around £0.50 for every £1 invested by EPSRC.
- The average Grand Challenge project is around £2.5 million of EPSRC funding compared to £290,000 for the remaining projects

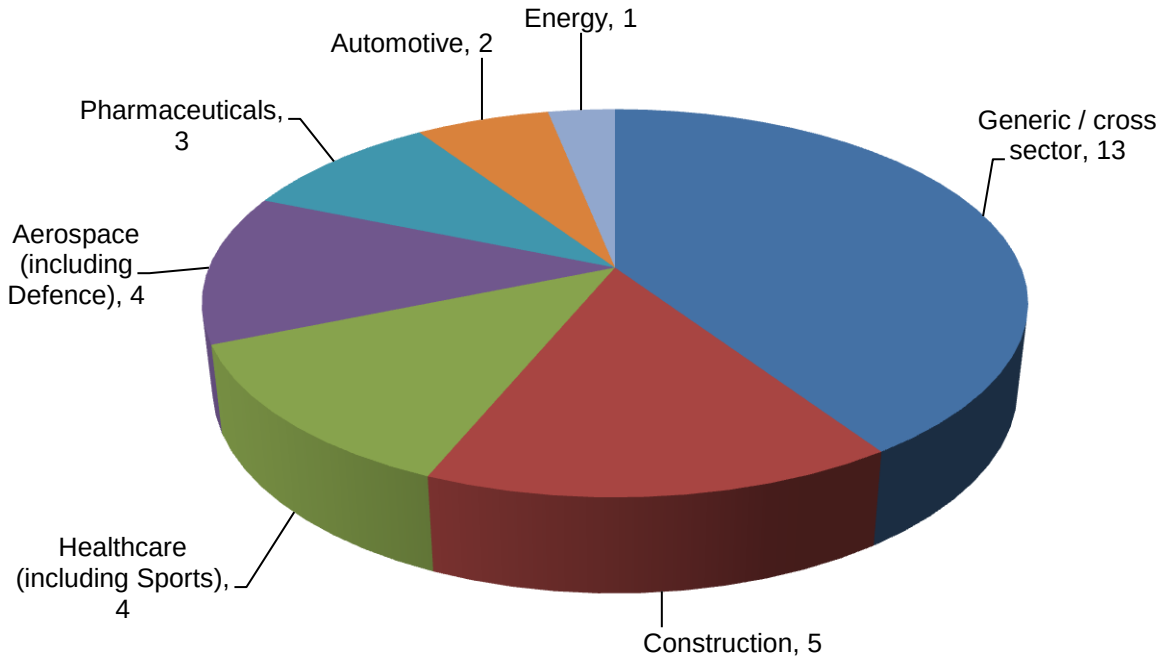
Figure 4.1 (Appendix A) provides a summary of all 32 case studies. The remainder of this section provides analysis and discussion of the case study impacts by sector and type of impact. Full case studies can be found in the detailed IMRC reports.

4.1 Sector Coverage

The selection of IMRCs for detailed review was intended to ensure coverage of a number of key manufacturing sectors. Figure 4.2 demonstrates that around a third of the case studies focus on research which is generic or relevant across a number of sectors. The selected case studies also include a range of examples of sector-specific research across a number of sectors: Construction (5 case studies), Healthcare (4), Aerospace (4), Pharmaceuticals (3), Automotive (2), and Energy (1).

[3] The 8 IMRCs reviewed were Bath, Cambridge IFM, Cranfield, Heriot Watt, Loughborough IMCRC, Reading ICRC, UCL, Warwick

Figure 4.2: Sector Focus of Case Studies



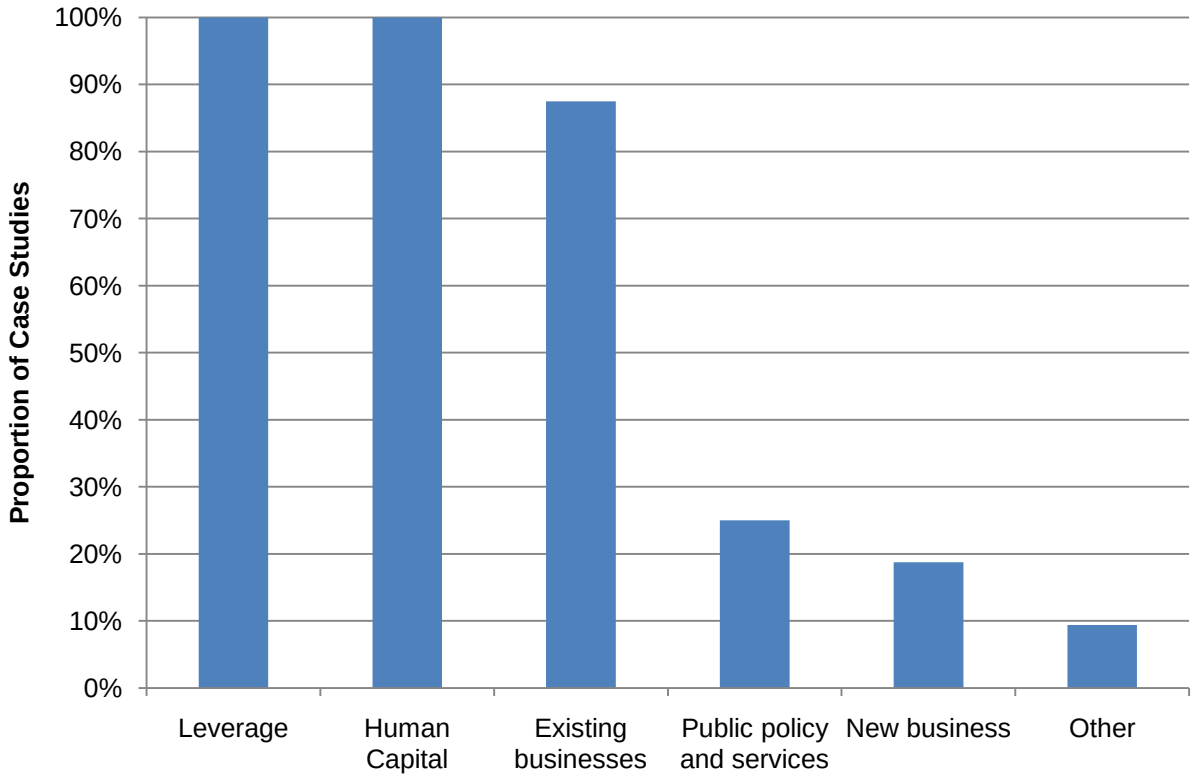
4.2 Economic Impacts by Type

The case studies selected have resulted in a wide range of economic impacts which have been categorised and summarised under impact headings used by BIS and EPSRC. These headings are:

- Improving existing businesses
- Creating new businesses
- Benefits to Public Policy and Public Services
- Leveraging Investment
- Generating Human Capital
- Other/wider impacts

Figure 4.3 provides a high level summary of the distribution of impacts across the different headings – in terms of frequency rather than significance (which is explored below). It should be noted that some case studies have impacts across more than one heading. There are examples of Human Capital and Leverage of Investment impacts across all case studies, and these aspects have also been considered at a whole-IMRC level.

Figure 4.3: Main Types of Economic Impact Generated by Case Study Projects



Improving Existing Businesses

As shown in Figure 4.3, the vast majority of case studies (88% of the case studies) have resulted in **Improvements to Existing Businesses**. In many ways the focus on business impacts is unsurprising given the level of collaboration between IMRCs and industry. The IMRCs were set up to foster this collaboration.

The case studies demonstrate how research can impact on existing businesses in a number of different ways – with the key gross impacts summarised and quantified in Figure 4.4:

Figure 4.4: Summary of Impacts on Existing Businesses

Type of Impact	Actual Gross Impact to Date	Potential / Future Impacts
Creating and safeguarding jobs	• 160 new jobs • 230 safeguarded jobs • This equates to a total impact of £63m (390 jobs multiplied by a GVA per worker of £54k[4], with a persistence period of 3 years[5])	• Potential to create/safeguard additional jobs due to associated impacts below (not quantified)

[4] Source: Annual Business Survey, 2009; the figure relates to the average GVA per worker in the Manufacturing sector, at UK level.

[5] The source of this assumption is the Impact of RDA Spending Report, PwC, 2009. The specific assumption relates to investments in science, R&D, and innovation.

Type of Impact	Actual Gross Impact to Date	Potential / Future Impacts
Safeguarding and increasing business sales or market share	• Supported £70m sales to date (either additional or safeguarded sales) • Supported growth in market share e.g. one collaborator achieved growth in the share of the European composite propellers market from 5% to 50%	• Potential for further increases in sales or market share across a number of collaborator businesses / sectors in the future (e.g. healthcare, coatings, electronics, defence, precision engineering, sports, construction, aerospace)
Assisting in the development and commercialisation of new products	• Assisting in bringing more than 20 new products/technologies to market • Licensing fees to date of £43 million	• Agreed licensing fees of over £400m contingent on future milestones being reached • Potential royalty payments of £130m p.a. on a single product • Three new products currently in licensing
Improving processes, resulting in cost savings	• Cost savings of £10 million p.a. • Reducing the cost of drug development by 50% in one firm	• Potential identified cost savings of up to £1.4 billion p.a. across the energy, construction, bioprocessing, automotive and aerospace sectors
Safeguarding businesses	• Helped to safeguard 2 businesses (both SMEs) at risk from closure	
Other impacts on existing businesses identified	• Improving manufacturing capacity in a business by 80% • Making businesses more adaptable to changes in demand • Improving planning/management of technology & R&D functions • Improving the chances of developing a successful product • Reducing the time taken to bring new products to market • Increased networking between companies (including across sectors)	

It is important to note that IMRC research has resulted in benefits both to individual collaborator firms, and to whole industrial sectors – the case studies include examples of both scales of impact. Many of the *actual* impacts to date identified relate to impacts on specific firms, although industry-wide impacts have been identified where possible.

It is likely that this assessment has underestimated the true impact across whole industrial sectors, as the pathway from research to impact is often extremely complex (explained further in Section 5), including through the transfer of human capital from one firm to another. However it is interesting to note that some of the IMRCs have been established on the basis of sharing all intellectual property generated within the IMRC with *all* collaborators; hence a large number of companies have indirectly benefitted from the research.

Creating New Businesses

19% of the case studies resulted in the **Creation of New Businesses,** with a total of **19 spinouts supported to date.** The examples can be summarised as follows:

- **China on Your Desktop** (Bath IdMRC) – 5 UK spinouts identified, plus 11 spinouts overseas. Whilst these are small companies they have significant potential to grow and to fundamentally change the future of manufacturing. The 'open source' dissemination of this research has been key to widening the scope of spinouts to overseas; and places Bath IdMRC and the UK at the cutting edge of research in this field.
- **New Metallic Coating Technology** (Cambridge IfM) – 1 spinout, with licensing agreement in negotiation
- **Managing Value Delivery in Design** (Loughborough IMCRC) – 1 spinout company (ADEPT Management Limited), which is exploiting the research outcomes and helping industrial take up.
- **House building as a Manufacturing Process** (Warwick IMRC) – creation of a new company with £13m of investment

Given that virtually all IMRC projects involve industrial partners, it has often been the case that new products have been taken forward through existing collaborator businesses rather than through spinouts. Therefore the balance of impacts is more skewed towards existing businesses rather than spinouts. For further discussion of this see Section 5 on Pathways to Impact.

Benefits to Public Policy and Public Services

One quarter of all case studies were identified as having benefitted **Public Policy and Public Services** (see Figure 4.3). The nature of these impacts varies considerably (as shown in Figure 4.5), from informing and reducing public expenditure, to informing public policy and industry standards. Impacts of this nature can indirectly feed through to impacts on businesses and taxpayers – for example through improving the effectiveness of public expenditure, reducing the tax burden of public sector activities to taxpayers, and through improving the competitiveness of the UK manufacturing sector.

Figure 4.5: Summary of Impacts on Public Policy and Public Services

Type of Impact	Actual Gross Impact to Date	Potential / Future Impacts
Informing public sector investment	• Influencing the allocation of public research funding • Informing a £36m new schools construction programme (Manchester City Council)	
Informing public sector policy/strategy	• Input into policy on bid-rigging (OFT) • Input into UKTI Export Strategy • Informing UK clinical trials policy	• Safeguarding UK clinical trials sector • Improving competitiveness of UK construction sector
Informing/inputting into standards	• Informing standards on tendering and consortia – for BSI, ISO and FIDIC	• Improving competitiveness of UK construction sector

Type of Impact	Actual Gross Impact to Date	Potential / Future Impacts
Cost savings to the public sector		• Potential cost savings in health (£4.3m p.a. plus an unquantified example) • Potential cost savings in defence (£13m p.a.)

In general terms, this type of impact has tended to be associated more strongly with management research.

Leveraging Investment

A number of examples of leverage of investment have been identified at IMRC and case study level, as summarised in Figure 4.6. All 32 of the case studies have resulted in direct leverage of cash and in-kind contributions – where data is available this shows that every £1 invested by EPSRC has resulted in an additional £0.80 in contributions from collaborators. In addition to this, some projects and IMRCs have resulted in significant leverage of income from overseas students, and some projects have resulted in bids for follow on funding from EPSRC, TSB and other sources.

Inward Investment has been considered at the IMRC level, as it has tended to relate to IMRC activity as a whole rather than individual projects. IMRCs have

Figure 4.6: Summary of Impacts - Leverage

Type of Impact	Actual Gross Impact to Date
Direct leverage of cash and in-kind contributions from collaborators	• Across all 15 IMRCs, the EPSRC investment of £192m has resulted in an additional £207 million of investment from collaborators. This implies a leverage of an additional £1.08 for every £1 invested by EPSRC. • The proportion of this leverage coming from overseas is generally quite modest at between 0-16% across the IMRCs. • 32 case studies reviewed in detail comprised an EPSRC investment of £17.95 million, and resulted in additional investment of £12.75 million. • However for 9 projects the level of leverage is unknown. Once these projects are stripped out, the ratio is £0.80 for every £1 invested by EPSRC.
Inward Investment (directly or indirectly supported by the IMRCs)	Examples include: • Tata Motors have invested £85million to date into a European Technical Centre based on the University of Warwick campus. The centre already has a team of 240 staff, and recently announced that they plan to increase this to 340 staff by 2013. This builds on the collaboration between Tata Motors and the Warwick Manufacturing Group (WMG), which includes researchers from the **Warwick IMRC.** • Investment of £5m+ by Boeing, Rolls Royce, Meggitt, BAE Systems and EEDA into an Integrated Vehicle Health Management Centre at Cranfield. In part this investment is due to the Servitization research theme within **Cranfield IMRC**, and the way in which the IMRC has conducted cross-disciplinary work. The Centre now employs 6 staff and interacts with 50+ academics from across the university. • **Cambridge IfM IMRC** has been working with SPI Lasers since 2003 to help develop industrial processing solutions and establish SPI as a leading provider of fibre laser systems. The IMRC established a world leading position in fibre laser systems research and SPI Lasers obtained expert knowledge of laser

Type of Impact	Actual Gross Impact to Date
	applications that help them establish new product lines. In 2009, SPI Lasers secured inward investment from the world leading laser systems builder Trumpf of Germany. This multi-million pound investment allowed SPI lasers to expand its UK operation in Southampton, thereby establishing hundreds of Jobs in the production of fibre lasers in the UK. • A **Loughborough IMCRC** project on eco-design and Recycling of Vehicles has led to GM wishing to support the future sustainable manufacturing research activities at Loughborough. Loughborough will become one of three UK Centres. Discussions are ongoing.
Supporting Inward Investment Promotion	• **Reading ICRC** staff regularly present to UKTI on construction exports, overseas collaborations, and the competitive position of the UK construction sector; and also participate in a UKTI Exports Group. • **Cambridge IFM IMRC** has had numerous engagements with UKTI including regular and fruitful work with UKTI sector specialists. IMRC staff have also helped to build links with India, presenting at major UKTI events in India and contributing to the development of an Industrial Innovation Forum in India.
Income from Overseas Students	• In addition to this, the IMRCs have supported the generation of significant sums of money from overseas students at all levels – for example Reading ICRC has identified fees from overseas students related to the centre totalling £6.8 million. (Note: it has not been possible to obtain corresponding estimates of overseas student fees for all IMRCs)

Follow on funding	• Another aspect of leverage is that several of the case studies have resulted in the development of successful bids for follow on funding, totalling around £39 million for the 32 case studies reviewed as follows:
	  ○ Regenerative Medicine Grand Challenge - £28m follow-on TSB funding
	  ○ 3D Mintegration Grand Challenge - £9.1m follow on funding
	  ○ UCL Allogenic Cell Therapy case study - £1.8m follow-on project with TSB
	• Some of the IMRCs are currently exploring future funding options beyond the current IMRC phase. An example is UCL, which has already secured commitments of £1.4 million from GSK to host two Centres of Excellence in Advanced Antibody Therapies and Antibody Formulation over the period 2012-2016. This work will build on the research undertaken within the IMRC.
	• In addition to the above, it is worth noting that many of the current IMRCs have developed proposals for new centres under EPSRC's Centres for Innovative Manufacturing programme – the results of which will be announced shortly. In many cases, the IMRCs have built on the existing network of collaborators developed within the current IMRCs; and have secured significant financial commitments from industry. This further strengthens the case that the IMRCs have developed strong networks with industry, and have provided industry-relevant outputs.

Generating Human Capital

Human capital impacts have been considered both at the level of individual case studies, and at the whole-IMRC level. A range of impacts are summarised in Figure 4.7, supported by examples from across the 8 IMRCs reviewed in detail.

Figure 4.7: Summary of Impacts - Human Capital

Type of Impact	Actual Gross Impact to Date

Staff	• The 15 IMRCs currently support 616 full-time equivalent members of staff.
	• The continuity of the IMRC model has allowed institutions to invest heavily in new members of staff. For example:
	  ○ Reading ICRC has facilitated the recruitment of eight new members of staff into the department, plus there are 5 instances of Research Assistants progressing to lectureships within the centre.
	  ○ UCL IMRC has allowed the department to expand its staff base by 50-60%

Recruitment into industry	• A high number of former IMRC staff and students are recruited into industry, delivering human capital gained in academia into the labour market. • The proportion of former staff/students recruited into industry is **50%** (weighted average based on proportion for the 8 IMRCs reviewed in detail). For some of the IMRCs, up to 70% of former staff/students are recruited into industry. • Examples of this include: ○ Cranfield – of the five case studies considered, 15 IMRC staff and students formerly involved in the projects have now been recruited into industry, generally by the industrial collaborators involved. • The remainder of former students and staff tend to move on, either to positions in academia or the public sector.
Academic and Industry Training	• The IMRCs have trained **1,331 PhD students** (including 690 completed to date and 641 ongoing) • On average, the lifetime premium (relative to 2+ A-levels) for PhD graduates in engineering and physical sciences is estimated at **£198,000**.[6] • This means that the total economic value of the PhDs trained by the 15 IMRCs in terms of the total uplift in lifetime incomes for these individuals is **£264m.** • IMRC staff also provide input into Bachelors and Masters level training. For example UCL IMRC staff provide inputs into the Masters in Bioprocessing Industry (MBI) programme, which has provided over **1,000 modules of training to 700 individuals from more than 200 companies to date**. • There are also examples of research outputs being used for training purposes – for example: ○ Cambridge IfM Strategic Technology Roadmapping Case Study - the IMRC have trained over 750 people since 2005 • The involvement of IMRC researchers in teaching enriches the student experience at all levels.
Knowledge exchange between academia and industry	• There are a number of methods by which knowledge is transferred between academia and industry cited by IMRCs: • PhDs gain knowledge from working with businesses at the cutting edge of industry. This experience prepares students for industry and improves their chances of securing leading edge research and commercial positions in industry. • Industry has gain raised awareness of technological improvements from academia • Postdoctoral students moving into industry can often act as a gateway to develop and enhance relationships between academia and industry. This is

[6] EPSRC (2010) EPSRC Delivery Plan 2008/09 to 2010/11

Type of Impact	Actual Gross Impact to Date
	supported further as in some cases individuals will return to academia bringing their industrial experience with them, which again benefits the university. • There are numerous examples of industry collaborators supporting and/or co-supervising doctoral students within the IMRCs. This has resulted in direct economic benefits to the industrial collaborators involved through the development of new products and services, improvements to the businesses, the recruitment of PhD/EngD students upon completion and improved absorptive capacity of firms. This mechanism for knowledge transfer is support by the IMRC model due to the high level of industry engagement and cooperation.
Improved absorptive capacity of industry	• Many consultees highlighted the importance of researcher mobility into and out of industry and academia. • This mobility builds the absorptive capacity of industry in terms of commercialising research outcomes. • It also opens doors into the academic research base through the networks of the academic staff involved. • These effects gain momentum over time and contribute to the impacts identified.

Other/Wider Impacts

A number of other wider impacts have been identified at case study and IMRC level which fall outside the above categories, as summarised in Figure 4.8:

Figure 4.8: Summary of Other/Wider Impacts

Type of Impact	Actual Gross Impact to Date
Environmental Impacts	• 10% of the case studies reviewed resulted in environmental benefits, as follows: ○ **Bath IdMRC, Packaging the Future case study** – potential to reduce waste to landfill by 40,000 tonnes p.a. ○ **Loughborough IMCRC, Design for Rapid Manufacturing case study** – potential to reduce air transport emissions by 36Mt CO_2e p.a., equivalent to savings worth £2.2 billion p.a. ○ **Warwick IMRC, House building as a Manufacturing Process case study** – energy savings equivalent to £9 million p.a., with a carbon value of £0.9 million p.a.
Capacity Building	• The IMRCs and host institutions have invested heavily in new buildings and equipment to take forward future research work. This investment will continue to provide a platform for future research beyond the life of the IMRCs. Examples of such investment include: ○ **Cranfield** – the university has invested £7.5m in equipment and buildings wholly or partly related to the IMRC ○ **Nottingham** – investment of £11.8m of funding from sources including TSB, EU, SRIF, and emda. ○ **UCL** – investment of £9.2m of funding from the Strategic Research Investment Fund, Gatesby Charitable Foundation, and Royal Society ○ **Warwick** – AWM/ERDF investment in facilities totalling £6.3m

Type of Impact	Actual Gross Impact to Date
Networks and Relationships	• The IMRCs have developed extensive networks with industry, policy, and academic contacts; which will to a large extent endure beyond the life of the IMRCs due to personal contacts and follow-on research collaborators. This point is closely linked to the human capital impacts. • The IMRCs have collectively collaborated with a total of over 700 firms – in many cases with several IMRCs working with the same firm, and making multiple contacts with firms. As already highlighted these are often deep collaborations over long time periods. • IMRCs have networked extensively with other internationally leading centres in their respective fields; and presented their work at international conferences.

4.3 Additionality and Attribution

In assessing the impact of the IMRCs it is important to consider both the Gross Impact (as summarised by Figure 4.9) and the Net Impact. The Net Impact is calculated by adjusting the Gross Impact to take into account additionality factors such as leakage, displacement, crowding out and attribution, as follows:

- **Leakage –** defined as the proportion of benefits which leak outside the defined area of benefit (which for Research Councils' activity would be the UK).

  The vast majority of case study examples primarily benefit firms which are either UK-based or have a UK presence. A small number of cases involve collaboration only with firms based wholly overseas. Therefore overall, the level of leakage is low. There are some issues associated with the measurement of leakage where multi-national firms are involved in IMRC projects – as their activities are dispersed globally, and some benefits of increased knowledge and increased turnover may partially leak outside the UK; however the extent of this appears to be low. The extent of leakage is partially determined by the sector focus of the IMRC – for example Heriot-Watt predominantly works with electronics companies, many of which are based overseas, as the size of the sector is relatively small in the UK. Warwick collaboration with Jaguar Land Rover benefits UK jobs despite its foreign ownership.

- **Displacement** – defined as the proportion of outputs/outcomes accounted for by reduced outputs/outcomes elsewhere in the target area. This is due to the intervention taking market share, land, labour or capital from other existing firms; and can be due to the supported activity taking up scarce resources, or driving up factor prices.

  In the case of the majority of research supported by EPSRC through the IMRCs, this is generally far from a fully commercial market opportunity and challenging. Hence, as described in Section 2 on market failure, firms are not able to justify investment on their own, and require public sector support to increase coordination and share risk. On this basis, the level of displacement is likely to be low, as firms are unlikely to undertake this research in the absence of public sector support.

  The only exception to this is in the case of near market applied research, where it could be questioned whether the IMRCs have gained market share at the expense of the independent research sector – which has been in decline for the last two decades. However, as explored in the

Hauser Review of Technology Innovation Centres[7] there have been a series of ongoing systemic shifts within the independent research sector from generic research to more commercially lucrative laboratory and technical consultancy services. Therefore it is possible that the decline in basic research being undertaken within the private sector is not due to competition from publically funded bodies such as the IMRCs, but due to other factors such as shifts in demand and commercial opportunities. The level of private sector leverage and the consultations with industry tend to support the benefits being additional rather than displacing company activity.

- **Substitution –** this is defined as where a firm substitutes one activity for a similar one to take advantage of public sector assistance. It can be thought of as 'within firm' displacement. This is not relevant to the investment in IMRCs as the investment has not been made in a firm but in a public sector organisation (i.e. a university).

- **Crowding Out** – this is defined as a situation where outputs generated as a result of an intervention are offset due to macro-economic adjustments, such as changes in inflation rates. Crowding out is associated only with extremely large public sector projects, which at the extreme can have a tendency to push up factor prices and cause inflation. Additionality Guidance suggests that Crowding Out can be ignored for interventions which involve less than 20% of the population or economy.

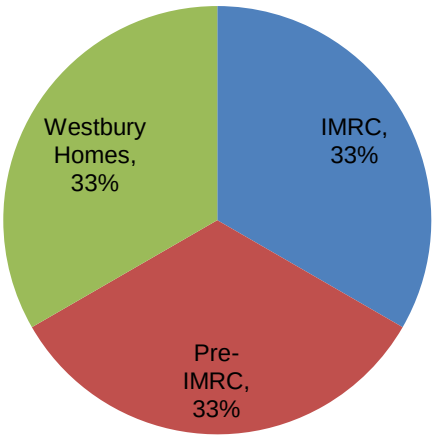
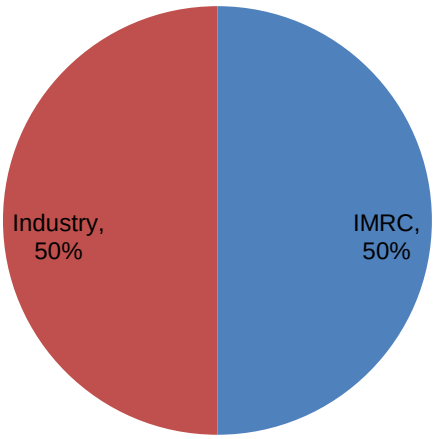
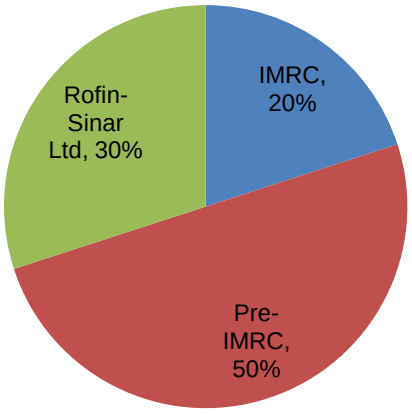
- **Attribution –** the final aspect which needs to be considered is the extent to which the outputs from IMRC projects can be attributed to the work of the IMRC as opposed to other parties or external factors. This also relates to the level of 'Deadweight', which can be defined as the extent to which outputs would have occurred in the absence of the intervention. The IMRC case studies have consistently highlighted a range of actors which have tended to contribute to the outputs related to IMRC projects:
    - **Pre-IMRC –** research undertaken prior to the creation of the IMRC – either by the IMRC institution or other institutions
    - **IMRC itself**
    - **Collaborators**
    - **Other agencies** (including other funding bodies such as TSB) – either during or after the involvement of the IMRC

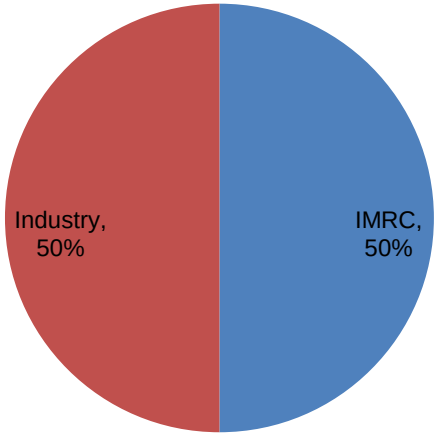
  In many cases, the work of the IMRC builds on existing research undertaken either by an IMRC institution or other institutions, so to an extent the outputs could be said to be partly attributable to this earlier research. In virtually all the case studies considered, the IMRCs have worked jointly with one or more collaborators, and therefore to an extent the research outputs can also be jointly attributed to the collaborators. In a smaller number of cases, the research has been taken forward by another party or agency since the involvement of the IMRC – for example through follow-on funding from an external funding body such as the TSB.

  There are issues with attempting to precisely attribute the research outputs and impacts between the main actors involved – as there is no way of precisely quantifying the extent and significance of the inputs of any of these parties. However, through discussion with consultees on a number of case studies, DTZ has been able to provide a **broad indication** of the attribution of impact between the various parties involved. The following are examples of where this has been possible (which have tended to be projects with actual impacts):

[7] BIS (2010) The Current and Future Role of Technology and Innovation Centres in the UK

Figure 4.9: Analysis of Attribution in Selected Case Studies

Involvement of Key Parties	Attribution
Warwick IMRC: House building as a Manufacturing Process The consensus view of consultees was that the impacts could be attributed as follows: • 1/3 of the impact can be attributed to Westbury Homes, based on research undertaken prior to the involvement with the IMRC • 1/3 of the impact can be attributed to research undertaken by Warwick University, but prior to the creation of the IMRC • 1/3 of the impact attributable to the work of the IMRC itself	
Loughborough: Regenerative Medicine • The impacts are a result of the IMRC and the industrial partner The Automation Partnership. Both parties played a significant role and invested a significant amount of time and resource in the project. • The consensus view of consultees was that the impact could be attributed 50%/50% between the IMRC and the industrial partner.	
Heriot-Watt: Pioneering Laser Technology The consensus view of consultees was that the impacts could be attributed as follows: • 20% could be attributed to the work of the Heriot-Watt IMRC during the period 2003-2010 • A further 50% could be attributed to Heriot-Watt, but related to the legacy of pre-IMRC research • The final 30% could be attributed to the involvement of the collaborator Rofin-Sinar Ltd	

Involvement of Key Parties	Attribution
Loughborough: Development of a New Exercise Platform • The consensus view of the consultees was that the impact could be attributed 50%/50% between the IMRC and the industrial partner Reebok. The IMRC collaborated with Reebok throughout the project, and Reebok subsequently took the research outputs forward, launching the new Reebok Deck product through their existing distributor networks.	

Overall, the selected case studies demonstrate that the proportion of impact which can be attributed to the work of the IMRC varies from 20%-50%. DTZ's view is that the selected case studies are typical of the IMRC work reviewed, and therefore an attribution of 20%-50% is a reasonable estimate to apply more widely.

4.4 Summary of Impacts

Drawing together all of the analysis from this section, Figure 4.10 provides a summary of all gross impacts generated by the IMRCs across all impact headings, together with a summary of additionality and attribution factors:

Figure 4.10: Summary of Impact

Gross Impacts - Case study level (32 case studies)	
Improving Existing Businesses (88% of case studies) • Creating 160 new jobs • Safeguarding 230 jobs • £70m additional sales to date • Growth in market share • 20 technologies/ products to market • Licensing fees of £43m • Cost savings £10m p.a. • Safeguarding 2 businesses • Increasing capacity, productivity, business planning, networking between companies	**Benefits to Public Policy & Services (25% of case studies)** • Influencing public sector investment • Informing public sector policy/ strategy (OFT, UKTI etc) • Informing new standards (ISO, FIDIC, BSI) • Potential cost savings to the public sector of £17m+ p.a. (NHS, MOD)
Creating New Businesses (19% of case studies) • 8 spinouts in the UK • 11 spinouts overseas – due to 'open source' nature of research	**Other (9% of case studies case studies)** • Environmental benefits - reduced emissions and waste to landfill

Gross Impacts - Case study level (32 case studies)	
Generating Human Capital (All case studies)	**Leveraging Investment (All case studies)**
• 50% of former staff/students recruited into industry • Co-supervision of PhDs / EngDs by industry • Successful Knowledge Transfer Partnerships and Knowledge Transfer Secondments	• Direct leverage of £0.80 - £1 for every £1 invested by ESPRC • Total leverage of £12.75m for the 32 case studies • Confirmed follow-on funding of £39m across the 32 case studies

Gross Impacts - IMRC-Level (for all 15 IMRCs as a whole)

- 616 FTE staff currently. The IMRCs have invested heavily in new permanent staff.
- Trained 1,331 PhD students, which corresponds to an estimated uplift in lifetime earnings of £262million.
- Contributions to academic and industry training - enrichment of student experience
- Leverage of £207m of cash and in-kind contributions across all IMRCs
- Directly and indirectly supporting inward investment into the UK, including providing support to UKTI
- Significant income from overseas students (e.g. £6.8m for Reading ICRC alone)
- Capacity building - investment in equipment and buildings
- Development of new networks and relationships
- Secondments with other institutions and industry

Additionality and Attribution

- **Leakage** – generally low as IMRCs have tended to work with collaborators with a UK presence (although leakage may be higher in the case of collaborative working with multinationals, but there are issues around recording/measurement)
- **Displacement** – generally low as IMRC research is generally at an early stage where there are market failures which prevent companies from investing in their own right.
- **Substitution** – not deemed to be relevant to the investment in IMRCs
- **Crowding Out** - not deemed to be relevant to the investment in IMRCs due to the scale of intervention
- **Attribution** – selected case studies have shown that between 20% and 50% of the impact can be attributed to the work of the IMRCs, with the remainder attributable to pre-IMRC work, and the involvement of collaborators and other parties/funders.

An indication of the Return on Investment (ROI) can be calculated by drawing together all of the monetised impacts from the table above, and comparing this to the amount invested. For the 32 case studies, this can be summarised as in Figure 4.11. Note that a persistence period of 3 years has been applied to all benefits expressed in annual terms.[8]

It should be noted that this analysis only includes actual impacts to date. As shown throughout this section, there are significant **potential impacts associated with these projects which have yet to be realised**. If these potential impacts were to be included in the calculations, then the impact figures would increase dramatically, although there is a risk that not all potential impacts will be realised.

[8] The source of this assumption is the Impact of RDA Spending Report, PwC, 2009. The specific assumption relates to investments in science, R&D, and innovation.

Figure 4.11: Return on Investment (32 Case Studies)

	Actual Impacts only
EPSRC Investment	**£17.95 million**
Gross Impact	**£289 million**, of which: • **£63m** of GVA generated by jobs created/safeguarded in the private sector (390 jobs multiplied by a GVA per worker of £54k[9], with a persistence period of 3 years) • **£5m** of GVA generated by jobs supported by the IMRCs - the total IMRC staff (616) have been pro-rated to reflect the share of total investment in the 32 case studies (9.3%) of total investment in the IMRCs, to give a figure of 57 staff. This is multiplied by a GVA per worker of £31k[10], and a persistence period of 3 years. • **£70m** additional sales to date • Licensing fees of **£43m** • Cost savings of **£30m** (£10m p.a., with a persistence period of 3 years) • Leveraged investment of **£13m** • Follow on funding of **£40m** • Increase in lifetime earnings of **£25m** associated with PhD training (these projects amount to 9.3% of total funding. This percentage has been applied to the total number of PhDs trained across all IMRCs (1,331) to estimate the number associated with these projects. The lifetime earnings uplift for PhDs versus non-PhDs is £198,000[11]).
Return on Investment	16.1 times the EPSRC investment
Net Impact	£57.8m - £144.5m (Assuming additionality of 20-50%)
Return on Investment	3.2 to 8.0 times the EPSRC investment

Considering only actual impacts to date, this implies a ratio of 16:1 between the gross impact and the investment by EPSRC in the 32 case studies. Once additionality (in particular attribution) is taken into account, this reduces to a ratio of net impact to investment of between 3.2:1 and 8:1.

If the Grand Challenge projects are removed from the calculation then the ratios change markedly, due to the fact that in general the Grand Challenge projects are at a relatively early stage, and have not had sufficient time to realise actual benefits; but nonetheless make up a significant share (55%) of the total funding for the 32 case studies reviewed. If the Grand Challenge projects are excluded then the Return on Investment is as follows:

- Total EPSRC investment: £8.147 million
- Total Gross Impact: £214 million (or 28 times the EPSRC investment)
- Total Net Impact: £43 - 107 million (or 5 - 13 times the EPSRC investment)

Given the long term nature of the Grand Challenge projects, and the fact that they have not yet had sufficient time to fully realise significant actual impacts, our view is that the return on investment figures excluding the Grand Challenge projects provide a fairer reflection of the overall investment in the IMRCs. On this basis, the **net return on investment lies in the region of 5 to 13 times the EPSRC investment** (depending on the level of attribution).

[9] Source: Annual Business Survey, 2009; average GVA per worker in the Manufacturing sector, at UK level.

[10] Source: Annual Business Survey, 2009; average GVA per worker in the Higher Education sector, at UK level.

[11] EPSRC (2010) EPSRC Delivery Plan 2008/09 to 2010/11

5. Pathways to impact

This section presents and discusses the different pathways to impact across all of the case studies. Figure 5.1 summarises these pathways from inputs through to impacts. It highlights the six main pathways identified through the case studies.

Figure 5.1: Summary of Pathways to Impact

EPSRC	
Total: £192m	Case studies: £18m, 9% of total

Leverage	
Total: £207m, 718 collaborators	Case studies: £12.8m, 6% of total

Resources	
616 staff	Buildings, facilities and equipment

Outputs			
1,088 projects	3,141 publications	67 patents	1,331 PhDs

Pathways					
Via collaborator	**Via policy makers**	**Via Licensing**	**Via Spin outs**	**Via Intermediates**	**Via Other means**

Impacts					
32 Case Studies	£70m additional sales	£10m Cost savings p.a.	£43m licensing fees	110 new jobs	230 jobs safeguarded
19 spinouts	Influencing public sector investment	Informing new industry standards	£39m follow-on funding	616 staff	50% former staff/students in industry

Figure 5.2 shows the frequency of the different pathways identified across the case studies. Given the focus of IMRCs on strong **industrial collaboration**, it is unsurprising that this pathway is the main route to impact identified in over 80% of the case studies. This route has resulted from the close collaboration between IMRCs and companies allowing a shared understanding of industry issues and problems to emerge and focused research projects that address them. These projects have levered substantial company investment in cash and time. Other mechanisms for achieving impact through this pathway include the Co-supervision of PhDs/EngDs by collaborators; and through Knowledge Transfer Partnerships (KTPs) and Knowledge Transfer Secondments (KTSs).

The types of impact emerging through this pathway include: new product development, new market entry, increased market share, improvements to business processes and cost savings. Section 4 also highlights the important human capital impacts resulting through collaboration, such as improved absorptive capacity in companies.

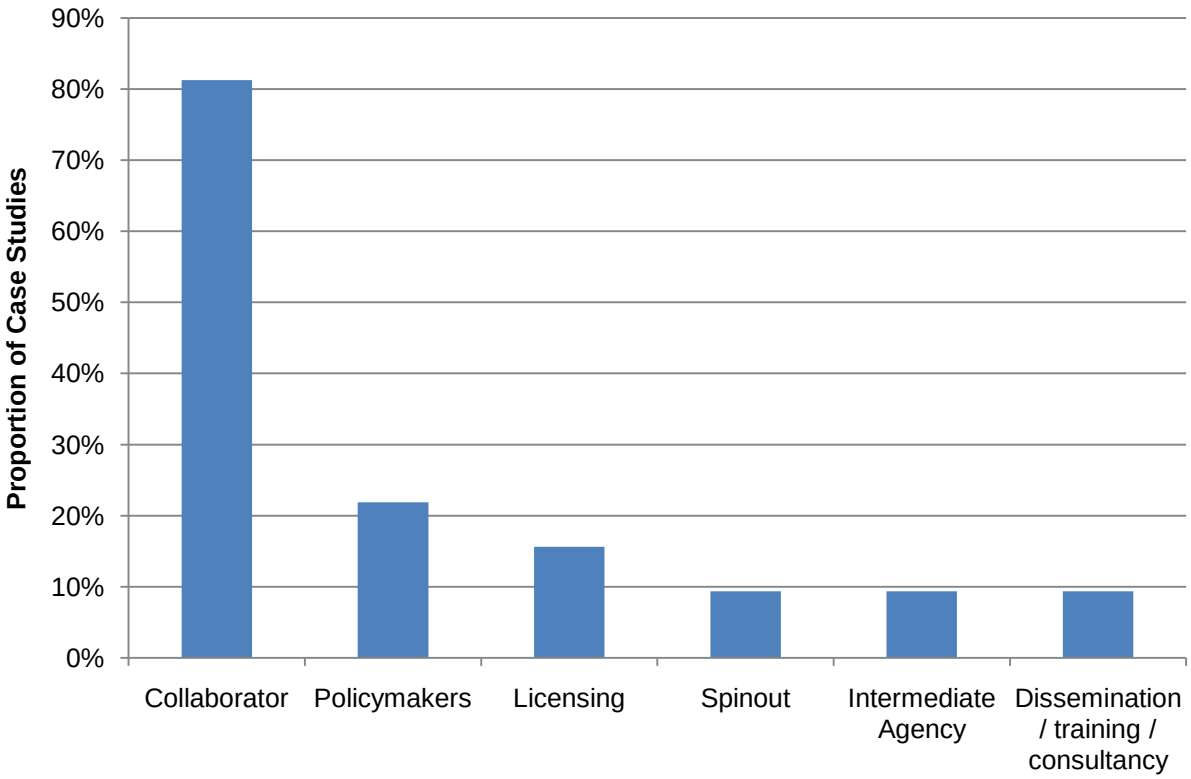
The second most frequently identified route is **via policy-makers**, which includes informing Government policy, development of industry wide initiatives and new industry standards. This pathway is identified in over 20% of case studies.

Licensing is the third most important pathway identified in 15% of the case studies while **spinouts** were identified in 10% of cases. The relatively low number of spin outs identified partly reflects the fact that IMRC industrial collaboration with existing firms is strong and partly the fact that licensing is often a preferred route. Clearly it is more efficient to use an established company to take a research project to market than it is to develop a new company with the additional costs and risks that this entails.

Intermediate agencies and **dissemination, training and consultancy** form the remaining pathways to impact – each accounting for around 10% of case studies.

There are no discernible trends in terms of the relationship between pathways and the different sectors covered by the IMRCs.

Figure 5.2: Frequency of Different Pathways to Impact



Highlights from the case studies across each of the pathways are summarised below:

- **Via Collaborator**
    - Bath IdMRC – 23 KTPs to date. 17 of the Knowledge Transfer Associates ended up being employed by the industrial partners following the KTP
    - Cranfield, Unmanned Aerial Vehicles – being taken forward by BAE systems
    - Cranfield, Pipe welding – being taken forward by BP
    - Cambridge IfM – project being taken forward by SPI lasers
    - Warwick, APPRAISE – taken forward with Jaguar LandRover
    - Heriot Watt, Pioneering Laser Technology – taken forward by Rofin-Sinar and Renishaw the main collaborators in the research
    - Loughborough, Development of new exercise platforms – taken forward by partners Reebok Fitness Equipment, Progressive Sport Technologies, and Playdale

- Loughborough, E-MEDIC – being taken forward by Vectura, one of the project partners
- UCL, Allogenic cell therapy Case Study – UCL IMRC worked with Onyvax to help develop a cancer vaccine for the late stage treatment of prostate cancer. This involved locating a doctoral student within the company to develop cell lines using IMRC methodologies.
- UCL IMRC - three KTSs involving the direct transfer of staff to UCB, BioPharm Services and GSK

- **Via Policymakers**
  - Reading ICRC, Competitiveness – developing new best practice standards in tendering and consortia, informing UKTI export strategy and assisting the Office of Fair Trading with ensuring fair procurement in construction
  - Warwick, House Building – informing Manchester City Council Schools programme
- **Via Licensing Agreement**
  - UCL, Process Development – assistance with product development led to product licensed to AstraZeneca for £195 million
  - Cranfield, Micro-coordinate measuring machines – licensing agreement currently under investigation
  - Cambridge IfM, Metallic Coating Technology - spinout company exploring licensing routes
- **Via spinout**
  - Bath IdMRC, China on your Desktop – 5 UK spinouts plus 11 international spinouts
  - Loughborough IMCRC, Value in Design – spinout company 'ADEPT'
- **Via Intermediate Agency**
  - Grand Challenges - Regenerative Medicine (£28million) and 3D Mintegration (£9.1million)
  - UCL, Allogenic Cell Therapy - £1.8 million follow on TSB funding
- **Via dissemination / publication / training / consultancy**
  - Cambridge IfM, Strategic Technology Roadmapping – trained 750 people in the use of the tools
  - Reading ICRC, Innovative Procurement – consultancy services for OFT, OGC, and various governments around the world

5.1 Assessment of Lessons Learned

As already highlighted, the IMRCs were set up with a strong focus on industrial collaboration so it is not surprising that this route is identified as the most common pathway to impact. However, it is important to highlight the feedback from consultees (IMRC and industry) about the quality of collaborations developed which have allowed these impacts to result.

The impacts are a result of long term, deep, strategic and well funded collaborations. The refocusing of IMRCs in Phase 2 has further enhanced the relationships. Actual impacts have already emerged but the timescales involved in bringing research to market mean that the potential impacts in the longer

term could be much larger. This assumes that the collaborations continue to be nurtured and developed.

The challenge of industrial collaborations as a pathway to impact is that the impacts are generally captured by one or a small number of companies. There is no incentive for these companies to share the benefits across their industry, especially if they have gained competitive advantage as a result. Whilst this may improve the competitive position of the individual firms, it may also displace activity of other UK firms. The evidence from the case studies tends to point to the companies assisted improving their market position and displacing overseas competitors rather than UK competitors. For example, SPI Lasers has become a global market leader, BAE Systems competes internationally. Jaguar Land Rover is a major UK employer and growing UK exporter. This suggests that the IMRCs have chosen to collaborate with suitable UK companies that will generate economic benefits for the UK.

At the other end of the spectrum from licensing, the open source software developed in the 'China on your Desktop' research is freely available globally and is spawning numerous spinouts. Whilst that means that the benefits cannot be controlled, it may also mean that the long-term impacts are greater as they are taken up more widely. Clearly there is a need for proper valuation and appropriate protection of intellectual property, but from a UK-wide point of view greater awareness of and access to research outputs might generate more long term impact.

For public policy or training/dissemination as pathways to impact, the benefits tend to be spread very widely, can be longer term, and are harder to quantify. On the other hand, if they influence a whole industry sector they may be of greater magnitude than impacts associated with one industry collaboration. The relatively small number of policy or dissemination impacts across the IMRCs makes it difficult to compare these pathways with the industry collaboration pathway. For IMRCs, the relatively small number of large companies in different manufacturing sectors would tend to suggest that industrial collaboration is the best pathway. For other sectors with larger number of smaller companies, industry wide or public policy collaboration might achieve more impact. The Strategic Technology Road-mapping undertaken by Cambridge for the automotive sector is a good example of industry wide training and dissemination.

Spin outs are relatively rare across the IMRCs. In general, spin outs are not necessarily the most efficient means of technology transfer due to the set up costs, need for management expertise and long timescales to impact. The spin outs identified in the case studies fall into two groups: the 'China on your desktop' spin outs are testing the new technology and are largely 'pre-market' and not significant in terms of turnover and profitability, whilst the other spin outs may have relatively low IMRC attribution. Compared to the impacts achieved through industry collaborations, spin out impacts are relatively small and long term.

Licensing agreements tend to be a more effective route than spin outs as they take advantage of existing company infrastructure. A number of licensing agreements are identified above. The problem is that confidentiality restrictions tend to make impact measurement difficult. It is likely that the impact resulting from licensing is under-reported across the case studies. Researchers may also not consider the potential value of their research and thus not put in place appropriate agreements with companies at an early stage.

The long term industry collaborations are the dominant pathway and a key feature of the way IMRCs were set up to operate. The added value resulting is highlighted in Section 6.

6. Added value of the IMRCs

Aside from assessing the economic impact of the IMRCs, one of the key objectives of this study was to identify the added value features of the IMRC model versus other more traditional funding models such as responsive mode funding. The purpose of this analysis is to identify and draw out the contribution of features of the IMRC model to adding value and maximising impact; from which lessons can be learned for the future. This assessment is based on the consultations with IMRC Centre Directors, and the researchers and industrial collaborators related to individual IMRC projects.

6.1 IMRC Features

In assessing the added value of the IMRC model, DTZ started by identifying features common across all IMRCs which define the IMRC model, summarised as follows. The added value of these features is discussed further below.

- **Continuity of funding** – the IMRCs have received guaranteed funding over a prolonged period – in most cases for 10 years across two phases.
- **Strategic approach to research** – IMRCs are all structured around a number of clearly defined research themes, as part of an overarching research strategy. The research strategy was defined from the outset, and in many cases has evolved over the duration of the IMRCs, particularly in response to external review.
- **Industry focus** – key to the IMRC model is the high level of engagement with industry. All IMRCs have a steering group consisting of senior industry leaders, which ensures that the research strategy and research projects are relevant to industry needs. Virtually all IMRC projects are undertaken in collaboration with industrial partners, ensuring a high level of buy-in and co-operation with industry.
- **Multi-disciplinary and cross institutional** (e.g. Grand Challenges) – the IMRC model has encouraged multi-disciplinary and cross-institutional working – particularly in the case of the multi-institution IMRCs (MATCH, HaCRIC, IeMRC), and the Grand Challenges.

These features are underpinned by:

- **Strong local governance and management, with devolved decision making** – all IMRCs have their own governance structure and robust local management team as described in Section 3, with clearly defined and effective systems for the approval of research projects in short timescales. Decision making on whether individual research projects should proceed is devolved from EPSRC to the IMRC, with IMRCs adopting local management processes to ensure that projects align with the stated research strategy.
- **International/peer review** – all IMRCs have been subject to an international peer review; most after around three years into Phase 1 of the IMRCs. There is strong evidence of the IMRCs responding to the findings of the reviews and adapting their research strategies accordingly.

Many of the above IMRC features are also found in other research centres and funding model; but perhaps the most unique feature of the IMRC model is the high level of engagement with industry – to a greater extent than is experienced in other research centres and funding models.

6.2 Added Value of the IMRC Model

Building on the above description of the IMRC model, analysis has been undertaken of the added value that these features bring, as summarised in Figure 6.1. This analysis draws on the consultations and examples from individual IMRCs, but it should be noted that all of the IMRCs identified similar linkages in terms of added value, and therefore these findings can be generalised to the IMRCs as a whole. It is also clear that there is considerable overlap between the added value of each of the features, and it is the **combination of all of these features** which has ensured the success of the IMRC model.

Figure 6.1: Added Value of the IMRC model

IMRC feature	Added value
Continuity of funding	• Building critical mass and capacity in terms of staff and industry links • Supporting a portfolio of both fundamental and applied research • Providing sufficient time and resources for research ideas to be developed fully • Benefits in terms of development of staff
Strategic approach to research	• Clear long term vision • Relevance to industry • Targeted investment in resources (buildings, equipment and staff)
Industry focus	• Industry linkages (university to industry and industry to industry) • Building long term deep relationships • Widening exposure to new companies and sectors • Leveraging funding and industry resources e.g. Data, equipment, Intellectual Property • Enrichment of staff and student experience with economic benefit resulting
Multi-disciplinary and cross institutional	• Creating novel solutions to problems • Knowledge exchange (between departments, cross institutions and with industry) • Creating critical mass and sharing resources • Developing deep relationships • Developing and raising the profile of host departments
Local governance and management	• Relevance to industry through steering group composition • Speed of response to funding requests • Further enhancing industrial linkages • Ability to take calculated risks with local knowledge
International and peer review	• Validation of research quality as internationally competitive • Ability to refine and change direction

These aspects are explored individually as follows:

Continuity of funding

- Building critical mass and capacity in terms of staff and industry links
- Supporting a portfolio of both fundamental and applied research
- Provides sufficient time and resources for research ideas to be developed fully
- Benefits in terms of development of staff

The continuity of the IMRC model supports the development of critical mass within the research centre and the wider department – in terms of human resources and industry/academic networks. Many IMRCs identified that the model allowed them to create greater linkages and exploit synergies within

and across departments more than previously, and share resources more effectively. One of the benefits of creating critical mass (as identified by Bath IdMRC) is that industry has multiple points from which to access research. Industry contacts sometimes come through one researcher, but are then exposed to the breadth of research that the centre carries out and can easily become involved in other areas. This aspect is very different to more traditional funding models which may be more siloed.

The continuity of funding model has also allowed the IMRCs to support a portfolio of research including both fundamental and applied research. There are many examples where an IMRC has made a speculative investment in a new research project which has resulted in a whole series of further research projects or even the development of a new research theme. This is supported by the longevity of the funding model, as it provides a sufficient timeframe and guaranteed funding to allow this to happen. There is a danger under responsive mode funding that research ideas are not developed fully as key staff leave or are redeployed before sufficient funding is secured. The continuity of IMRC funding also encourages greater resilience, by embedding knowledge within the centre rather than an individual. Examples of this include Reading ICRC, where a small initial investment in research around construction procurement has resulted in a further £900,000 of funding over a period of 10 years; and Loughborough IMCRC, where a seed investment in Regenerative Medicine has resulted in a whole new £28million research programme funded under the Centres for Innovative Manufacturing programme.

These views are endorsed by many of the companies which have collaborated with IMRCs. For example, Rofin-Sinar UK and Renishaw plc collaborated with Heriot-Watt IMRC on a long term series of research projects each one building on the achievements of former research work. The collaborators commented that the IMRC model has provided the level of resources and time-frame to allow a novel approach in facilitating 'blue sky' thinking.

The Research and Development Manager at Renishaw's Edinburgh facility sums up the key attributes of the IMRC funding model as follow:

> "*Without the responsiveness of IMRC model, we could not have built up this strategic academic-commercial relationship with Heriot-Watt University. We would have had to resort to the 'old model', based on short, focused, small pieces of work. Renishaw's contribution would have been less and the returns would have been modest. We would have been scratching the surface rather than achieving a major impact in 5 years time."*

Researchers from Heriot-Watt comment that this was a real challenge for all of the academic team members: "....*it took us 18 months to stop thinking incrementally and to start thinking outside the box.*" This sea-change in their research methodologies could not have been achieved under the more traditional research funding route.

There are also benefits in terms of the development of staff. Bath IdMRC commented that the IMRC model allows more junior staff to gain experience as co-investigators earlier than would otherwise be the case through responsive mode grants. This gives junior researchers more credibility and management experience, and supports them to develop their own ideas and interests.

Strategic approach to research

- Clear long term vision
- Relevance to industry
- Targeted investment in resources (buildings, equipment and staff)

A common feature across all of the IMRCs is that they all have all developed a highly **strategic approach to research**, with a number of clearly defined research themes. The requirement for an overarching research strategy was key to the application process to gain IMRC funding. Overall, the strategic approach to research has ensured that the IMRCs have a clear **long term vision**; from which

all other activity has stemmed. This has made research activities more coherent, encouraged greater co-operation between researchers and improved efficiency. Reading ICRC commented that *"the centre is more coherent than previously, with more interaction, communication and cooperation between individual researchers. The IMRC model encourages greater efficiency due to the removal of duplication in industry interaction."*

This view is supported by UCL IMRC staff, who commented that the IMRC model *"encourages greater co-production and sharing of research between researchers. Researchers work more closely together, making them more aware of what other work is being undertaken in the centre. The organisation of work into themes means that research effort is more focused on critical issues.*" UCL also identified that the IMRC model has raised the profile of the research being undertaken, as industry finds it easier to engage with a centre of critical mass as opposed to a dispersed set of individual project holders.

There are also benefits in terms of locating each research project within a strategic whole rather than conducting projects in isolation. Bath IdMRC identifies that whilst it may have been possible to attract similar levels of funding through open calls, this would have lacked strategic focus, and would have made it more difficult for researchers to fully explore and develop their ideas. Similarly, Cambridge IfM described how the strategic focus of the IMRC model had allowed them to develop an 'Emerging Industries Research Programme'; and that there has been benefit of tackling this research area as a whole rather than as a series of one-off research projects. IMRC funding has enabled Cranfield to identify key manufacturing research priorities which combine its research strengths with the needs of its user community in the manufacturing sector. Cranfield identified key manufacturing issues where relatively little academic research had been undertaken, and the IMRC enabled it to structure a research programme around these issues.

The IMRC research strategies have all been developed in partnership with IMRC industrial steering groups, which ensured the **relevance of the research to industry needs**. The research strategies of the IMRCs have evolved over time, based on shifts in industry needs and the findings from the EPSRC international peer reviews. In many cases, the peer reviews resulted in the IMRCs refocusing and consolidating down to a smaller number of research themes, and a greater focus on high quality, globally leading research (this is discussed further below). Staff from Loughborough IMCRC reported that the more strategic approach led to them addressing industrial research problems with a much higher level of ambition than previously, and that they have been able to take more innovative steps to addressing problems.

Based on their research strategies, the IMRCs and their host institutions have been able to make targeted investments in buildings, equipment and human resources, for example:

- **Reading ICRC** - The strategic focus and longevity of the IMRC model has allowed greater **long-term investment in human capital,** with appointments within the ICRC made on the basis of the overall research strategy, rather than fit with individual projects. For example, there were three recruits made specifically to bolster Reading's research capability in specific areas, and the ICRC has also facilitated the recruitment of six other permanent academic staff.
- **UCL –** investment of £9.2m of funding from the Strategic Research Investment Fund, Gatesby Charitable Foundation, and Royal Society has been made into new equipment and buildings. The department has increased its human resources by 50% due to IMRC funding.
- **Cranfield** University has invested £7.5m in equipment and buildings wholly or partly related to the IMRC; whilst **Warwick IMRC** has secured investment in facilities totalling £6.3m from AWM/ERDF sources.
- **Loughborough IMCRC –** invested in a new Sports Science Institute (with investment from emda), and involved in a new Manufacturing Technology Centre at Coventry (with investment from AWM and emda)

There are linkages between the strategic focus of the IMRCs, the continuity of funding, and the industry focus; all of which have contributed to the strength, quality and relevance of the research.

Industry focus

- Industry linkages (university to industry and industry to industry)
- Building long term deep relationships
- Widening exposure to new companies and sectors
- Leveraging funding and industry resources e.g. Data, equipment, Intellectual Property
- Enrichment of staff and student experience with economic benefit

One of the distinguishing features of the IMRC model versus other models of funding is the level of **industry interaction and engagement**. This comes at a variety of levels – with firms providing input into the research strategies of the IMRCs through the industrial steering committee comprised of senior industrialists, as well as collaborating at the individual project level. There are many examples of large firms collaborating across several of the IMRCs – indeed the IMRC network appears to have facilitated this connectivity due to the linkages between institutions, Grand Challenges and multi-institution IMRCs (see below for further discussion of this aspect).

The longevity of the IMRC model has allowed the researchers involved to develop **deep interactions** with firms and whole industry sectors – often through a series of linked research projects. An example of this is at Warwick IMRC, which has collaborated extensively with major automotive companies such as Ford and Jaguar Land Rover, and firmly embedded the centre in the industry. Jaguar is currently working with Warwick as it looks to develop hybrid vehicles – with around 100 Jaguar employees working at Warwick Manufacturing Group on this research. Similarly, Loughborough has developed deep relationships with Ford and Reebok, over a series of linked projects. In the context of the Knowledge Information Management Grand Challenge project, engineering firm ABB collaborated extensively with the IMRCs – estimating that the collaboration totalled around 200 days of ABB staff time, including involvement by ABB's Senior Vice President.

The following quotes further reinforce the strength of relationships between the IMRCs and industry, and the impact this has created within industry:

> *"The collaboration with the Cambridge IMRC through Dr Bill O'Neill was important in driving forward product development and vital in helping us to establish credibility and presence in a completely different market place to where we started."* **Dr Malcolm Varnham, Vice President of Intellectual Property at SPI Lasers**
>
> *"The input from the Cranfield IMRC team was invaluable on this project; in particular, the ability of the university to bring a network of businesses to the project. We expect the EEE Force Tool which has been informed by this research to give us greater control of equipment support costs in terms of the risk from obsolescence and to save costs in the future."* **Stuart Kelly, Obsolescence Manager Policy Lead at MoD**
>
> *"The research project created a trusted network of companies with people sharing not only explicit, but tacit information that would not normally have been disclosed. There is much work still to be done but it has given all the companies involved a new insight into costing techniques that can be used to grow the UK's share of the global defence market."* **Phil Wardle, Business Improvement Manager at BAE Systems**
>
> "*There is no way we could have developed this technology ourselves. The IMRC project represented an ideal opportunity to work together. We do not have the knowledge and expertise to develop new materials but it is one of the ways in which we can innovate and develop our products. Cranfield had a new material but no route to take it to market. This project was a*

golden opportunity to work together and we certainly intend to continue this relationship." **Chris Gerrard, R&D Manager at Westwind Air Bearing Spindles**

"*We made a real breakthrough at NPL in coming up with a completely different type of probe design, but we needed help to turn it into a practical device. The specialist knowledge and skills at the IMRCs and other universities helped us to turn the research into a practical device which is in the process of being commercialised*" **Professor Richard Leach, NPL**

"The underlying principle of the KIM Project – providing the right information in the right context at the right time – is at the heart of our business proposition. In addition to the enormously useful insights gained into the information management problems that we face every day, engagement in the KIM Project and its knowledge transfer activities has proved very useful in developing our Group Knowledge Management Strategy. The outputs of the research have been useful in bringing together silos of knowledge and information – both within Balfour Beatty itself, and between the firm and academia."
Simon Flint, Business Development Manager, Balfour Beatty

'The work done by Professor Hughes at Reading ICRC is extremely detailed, and far more illuminating than any other source of information or insight. There is no-one who has helped me to understand the specific processes of the UK construction industry more than Professor Hughes.' **Tom Dengenis, former Chief Executive of Asite**

The IMRC model has also helped to **widen the interaction** of institutions with larger numbers of firms – for example the UCL IMRC has been able to greatly increase the number of firms in its network through active selective recruitment, and now works with close to 90% of firms in the bio-processing industry.

The industry engagement has ensured that the research undertaken by the IMRCs is **aligned to industry needs**. There are strong linkages here between the industry focus and strategic approach to research discussed above. With an industry-tested research strategy in place, the IMRCs have been able to identify and take forward industry relevant projects – as discussed below; the IMRCs have robust processes in place to ensure the fit of project proposals against agreed research themes. In bringing forward project proposals, researchers are required to consider the fit against strategic research themes, and the potential impact on industry. According to the Chairman of Heriot-Watt IMRC, due to the interaction between the researchers and the industrial steering committee *"it is now second nature for academics to 'think commercial"*. Industrial partners are also able to input into research ideas, leading to a **co-production model of research**. Reading ICRC is frequently cited as an example of best practice in co-production of research, and connectivity and interaction with industry.

Another benefit of the industrial engagement is the significant **leverage of investment from industry**. As discussed in Section 4, the £192 million investment by EPSRC has resulted in a further £207 million of leverage from industry; 25% of which is cash, and the remainder is contributions in kind. Whilst the cash makes a direct contribution to the cost of undertaking research, the contributions in kind can also be extremely valuable – for example access to equipment or confidential data. For example, UCL identified that through IMRC work they have gained access to new cell lines in development by pharmaceutical companies, and to high-value pieces of industrial equipment. This has been invaluable to the IMRCs in allowing them to test their new analytical techniques on cutting edge industry problems; and prior to the IMRC it had not been possible to gain such access to industry resources.

Another benefit of the model is that it allows the IMRCs to be **more responsive to industry**. Bath IdMRC identified that the strategic alignment to industry interests, coupled with devolved decision-making allows the IRMCs to respond very quickly to industry needs – with no need to apply for additional funding to take projects forward. This sometimes makes the difference in terms of gaining industry support, as opportunities can be time-limited.

Benefits also come through the new **business-to-business connections facilitated by the IMRC**. An example of this is through the Knowledge Information Management Grand Challenge project, where around 40 firms were involved across a number of sectors. This included benchmarking work on information management systems across a number of sectors, and has resulted in new industry interactions and sharing of best practice across sectors where there was previously little connection. Another example relates to UCL IMRC, where the IMRC model has "**energised companies to work together on common issues" -** partly due to the fact that all IMRC findings and Intellectual Property is made available to all collaborators. This has resulted in a cross-fertilisation of ideas, sharing of information, and a more rapid development of the industry as a whole.

Multi-disciplinary and cross institutional

- Creating novel solutions to problems
- Knowledge exchange (between departments, cross institutions and with industry)
- Creating critical mass and sharing resources
- Developing deep relationships
- Developing and raising the profile of host departments

Another added value feature of many of the IMRCs is the high level of **multi-disciplinarity and cross-institution working**. The larger IMRCs involve staff across several university departments. For example Loughborough IMCRC has staff from seven departments - Mechanical Engineering, Civil and Building Engineering, Computer Science, Ergonomics and Safety, Design and Technology, Electronic and Electrical Engineering and the Business School. Loughborough IMCRC has also worked with other institutions; for example the E-Medic project drew in support from Bath and Southampton, while the Regenerative Medicine Grand Challenge included Birmingham, Cambridge, Liverpool, Nottingham and Ulster. This approach encourages the **development of unique solutions, creates economies of scale, and encourages the sharing of resources between departments**. Reading ICRC highlighted that the IMRC model facilitates improvements in efficiency, by encouraging greater sharing of industry contacts and 'cross-selling' the work of other researchers.

Another example of how the IMRC model has fostered greater joint-working is the Product Service Systems programme at Cranfield IMRC. The centre used two ideas factories / sandpits as part of the development of the programme; bringing together academics from across the university and external representatives to identify research priorities and to develop initial research ideas into projects. There are now joint projects between academics in the School of Applied Sciences and the School of Management which would never have happened before the establishment of the IMRC. The Cranfield IMRC commented that this is a *"step-change from the 'research silos' that used to exist in the past".*

Heriot-Watt IMRC identified that the bringing together of skills and expertise from different academic schools under the IMRC model has helped them to:

- Bring together multi-disciplinary teams more effectively than would otherwise have been the case;
- Identify, tackle and exploit research areas more effectively through a multi-disciplinary approach. *"You have a much bigger pool of expertise to draw upon – colleagues you can bounce ideas off"*;
- Share research staff, resources and ideas within themes and between themes much more effectively
- Exploit economies of scale through the larger critical mass of the centre

The IMRC network has also facilitated cross-institution working. Partnerships of universities deliver three multi-institution IMRCs and the four Grand Challenges:

Multi-institution IMRCs

- HACRIC (Health and Care Infrastructure Research and Innovation Centre) – a collaboration between Imperial College London, and the Universities of Loughborough, Reading and Salford.
- MATCH (Multi-disciplinary Assessment of Technology Centre for Healthcare) – led by Brunel University in collaboration with the Ulster, Nottingham and Birmingham Universities.
- IeMRC (Innovative Electronics Manufacturing Research Centre) – led by Loughborough University together with seven other universities.

Grand Challenges

- 3-D Mintegration (abbreviation for 3D Miniaturised/Integration) - 4 IMRCs plus 3 other research centres
- KIM Grand Challenge Project (Through-Life Knowledge Information Management) - 8 IMRC's plus 5 other departments from 11 different UK Universities
- Regenerative Medicine (ReMedi) Grand Challenge - 4 IMRCs and a number of other collaborators
- Innovation and Productivity Grand Challenge - 5 IMRCs involved

The Grand Challenge projects have managed to **galvanise significant commitment by universities and industrial partners**, with researchers identifying that the level of commitment and co-operation has been greater than other models of partnership working in the UK university sector. Grand Challenge researchers identify that this has resulted in deeper relationships with industry than would otherwise be the case, and has fostered greater levels of **communication and co-operation between institutions and with industry**. This model has led to some interesting new linkages between industry partners which are unlikely to have occurred otherwise – for example the cross-industry comparisons made within the KIM Grand Challenge project have forged linkages between firms in completely different sectors.

Local governance and management

- Relevance to industry through steering group composition
- Speed of response to funding requests
- Further enhancing industrial linkages
- Ability to take calculated risks with local knowledge

International and peer review

- Validation of research quality as internationally competitive
- Ability to refine and change direction

The final distinguishing feature of the IMRC model is the **robust governance, management and administrative processes**. As set out in Section 3, all of the IMRCs have a strong governance system, with a Centre Director supported by an industrial steering group and management committee. The purpose of the Industrial Steering Group is to input into the research strategy and ensure that it meets industry needs. The Internal Management Committee has an influence in terms of the approval of projects, and ensures that all projects align with the research strategy. With these processes in place, the IMRCs have ensured the **relevance of research projects to industry**.

Related to this, the devolution of decision making from EPSRC to the IMRCs means that the IMRCs can be extremely **responsive to industry**. The IMRCs can respond quickly in the exploitation of opportunities identified with their commercial and academic partners. The traditional approval route for EPSRC funded research projects could take up to 12 months, whereas through an IMRC, researchers can submit a research proposal and have it approved by the Steering Committee within a matter of weeks.

A number of IMRCs commented that this has allowed them to take **calculated risks in funding exploratory research** – which would have been difficult to fund through other routes such as

responsive mode grants. For example the RepRap project at Bath IdMRC was allocated initial funding of £20,000. In this case the time taken to respond to an open call would have been too great due to the riskiness of the project – but researchers could see its potential, and this has since led on to further research. Similarly Cambridge IfM IMRC took a significant risk in investing £600,000 in developing a high power fibre laser, but the IMRC staff had in-depth knowledge of the research area and the team and was confident in its capabilities. The risk, which might have been too much for others, has paid off, and has led to significant economic impact to date such as the safeguarding of employment within SPI Lasers – a UK-based high-tech SME employing 210 staff.

In these cases, the researchers in question report that these were risky investments to take; but that they could see the merits in this research and it was clear that the research aligned with their overall strategy. The devolution of authority to the IMRC level allowed the principal investigators to assess the potential of the research – and in many ways the PIs are well-placed to make this assessment due to their knowledge of the research area and of industry.

Another strength of the IMRC governance system has been the **International Peer Review process** undertaken by EPSRC in partnership with the IMRCs. All of the IMRCs have gone through an international peer review – typically around three years into the IMRC funding. The purpose of the international reviews was to ensure that the IMRCs were **focused on high quality research of international importance**; making recommendations as to how this could be achieved. In many cases the peer review process resulted in far more **coherent and focused research strategy** in Phase 2; and in some cases a reduction in the number of research themes. For example, in the case of Reading ICRC, the centre had six research themes in Phase 1 – each focused around one or more grants funded under the previous Innovative Manufacturing Initiative. Following the International Peer Review, the research strategy was consolidated down to three themes. Similarly, Warwick IMRC consolidated from six research themes in Phase 1 to just 2 themes in Phase 2 – with a refocusing towards major research challenges that were particularly relevant to the UK.

7. Conclusions

To conclude, it is clear that the IMRCs really do add significant value – in terms of concrete quantified benefits to existing firms, new business creation, improvements to public policy and public services, human capital benefits, leverage and wider benefits. The impacts and benefits of the model are universally recognised. Whilst the research undertaken has its limitations (Section 2) these limitations are likely to lead to an under-estimate the full economic impacts of the IMRCs.

Whilst there has already been significant actual impact to date, the impacts in the future could be even greater. The IMRCs have only really had a limited time to develop. Whilst some centres have been funded for 10 years, it is clear that it took a number of years for the IMRCs to develop coherent research strategies – assisted in part by the International Peer Review process from 2003 onwards. Most IMRCs consolidated and refocused their research strategies in Phase 2 (from 2006 onwards). It also took some time to build industrial relationships – but these are now extremely well developed. Given that many basic research projects can take up to 10 years or even longer to result in actual impacts; the review has tended to identify examples where actual impacts are feeding through now – or are anticipated in the next few years.

Overall, the 32 case studies considered, which represent £18 million or 9% of the IMRC budget demonstrate strong economic benefits relative to the investment made by EPSRC. The return on investment is in line with that established in other assessments of research programmes undertaken by DTZ.

Looking forward, a number of IMRCs are already considering the next steps for their research. It is clear that the IMRC programme has resulted in strong industrial networks and collaborations, and innovative projects; but that further time and investment may be required in order to fully maximise the investment to date. Many IMRC institutions have responded with bids to the new Centres for Innovative Manufacturing programme – which has allowed them to build on and enhance their existing industrial relationships and explore new areas of research. It is notable that many of the collaborators within the IMRCs have made significant commitments towards the Centres for Innovative Manufacturing programme.

Another route being explored by the IMRCs is effectively an 'IMRC Phase 3' in which the IMRC institution is involved in further knowledge-transfer activities based on the research undertaken and knowledge developed through the IMRC Phases 1 and 2. An example of this is UCL IMRC, which is currently working on a business plan for further research activity. UCL have already entered into an agreement with GSK to host a Centre of Excellence in Advanced Antibody Therapies, which will provide funding of £1 million over 4 years; and an additional Centre of Excellent on Antibody Formulation (£0.4 million). These centres will build on the intellectual property held within the IMRC, and operate under the IMRC label. This approach has a potential for a greater private sector contribution, and potentially even a private-sector led model; and could potentially be rolled out to other IMRCs.

Given the timescales involved in generating impact from research and the fact that many IMRCs refocused after Phase 1, it is still early days for actual impacts to emerge from the IMRCs. We would therefore anticipate that continuing impacts will emerge from the research over the next 5-10 years.

Appendix 1: Summary of Case Studies

Figure 4.1: Summary of Case Studies

IMRC	Description	Funding	Summary of Actual and (Potential) Impacts	Sector Focus
Bath	Packaging the future – understanding of machine-material interfaces in packaging processes	IMRC: £640k Other: £532k	Usage of software outputs by industry Materials cost savings of £1m p.a. (Potential to result in material savings of 13%, resulting in cost savings and a reduction of waste to landfill of 40,000 tonnes)	Packaging
Bath	Stepping into the future – design of a new process of cryogenic machining	IMRC: £210k Other: £28k	Additional sales to date of £100,000 (medical insoles) (Potential to grow UK market for bespoke orthotics and insoles, and reduce costs to the NHS)	Generic / cross sector
Bath	China on your desktop – rapid prototyping technology	IMRC: £70k Other: £7k	16 companies worldwide have come out of the project to date - including 6 in the UK (Potential to revolutionalise advanced manufacturing & distribution)	Generic / cross sector
Bath	Though Life Knowledge Information Management (Grand Challenge)	IMRC: £813k Other: £204k	Unquantifiable improvements to existing businesses (Potential to improve efficiency by reducing the time spent by engineers looking for information)	Generic / cross sector
Bath	Walking Worker Manufacturing Systems	IMRC: £131k Other: £23k	Improving existing manufacturing businesses by: Increasing capacity by 80% Making them more flexible and adaptable to changes in demand (Potentially improving system capacity by 6.3%)	Generic / cross sector
Cambridge	New Metallic Coating Technology	IMRC: £270k Other: N/A	Spin-out company established, and a license agreement is currently being negotiated. The global paint and coatings market for this product is forecasted to be £70 billion by 2013. (Potential to reduce the costs of hip replacements, resulting in a saving of £4.3m p.a. to the NHS)	Generic / cross sector
Cambridge	High power fibre lasers	IMRC: £600k Other: £300k	Helping to safeguard an existing SME, safeguarding 210 jobs, and £40m of turnover. (Potential to support the growth of the collaborator business – with a doubling of turnover year on year)	Generic / cross sector

IMRC	Description	Funding	Summary of Actual and (Potential) Impacts	Sector Focus
Cambridge	Strategic Technology Roadmapping	IMRC: £346k Other: £92k	Influencing the allocation of public research funding Assisting companies and other organisations to plan and manage their technology / research functions more effectively Over 750 people trained in road-mapping since 2005	Generic / cross sector
Cranfield	Whole Life Cost Modelling of Product-Service Systems	IMRC: £393k Other: £749k	(Potential to reduce UK government defence costs – indicative estimate of £13m p.a.) (Potential to help UK defence manufacturers win more business in global defence markets)	Aerospace / Defence
Cranfield	Airframes for Next Generation Unmanned Air Vehicles (UAVs)	IMRC: £135k Other: £239k	(Potential to help UK manufacturers win a share of the growing market for UAVs. A 1% share of this market would represent £74m p.a.) (Potential to support innovation and product design in other sectors)	Aerospace / Defence
Cranfield	Pipe welding System for the Construction of Oil and Gas Pipelines	IMRC: £700k Other: £1.5m	(Potential to result in cost savings of £1billion p.a. in the pipeline construction industry)	Energy
Cranfield	Porous Ceramic Air Bearing Technology	IMRC: £30k Other: In kind	(Potential to safeguard the competitive position of a UK manufacturing company, and enhance the competitive position of UK precision engineering sector)	Generic / cross sector
Cranfield	Micro Measuring Machines	IMRC: £34k Other: £52k	A license agreement is currently in negotiation. (Potential to result in a new range of Micro Measuring Machines) (Potential to result in more accurate measurement in manufacturing, estimated as generating £68m of additional economic activity in the longer term)	Generic / cross sector
Heriot-Watt	Pioneering laser technology	IMRC: £669k Other: £302k	Growth in turnover in one company of £9.5m to date Supporting an increase in employment of 50 staff (Potential to provide wider benefits to the global laser industry)	Generic / cross sector
Heriot-Watt	Optical shape measurement	IMRC: £130k Other: £334k	Creation of 17 new jobs Safeguarding of 20 jobs	Generic / cross sector
Heriot-Watt	3D Mintegration (Abbreviation for Miniaturised Integration) Grand Challenge	IMRC: £4.2m Other: £2.3m	(Potential to improve manufacturing processes)	Generic / cross sector

IMRC	Description	Funding	Summary of Actual and (Potential) Impacts	Sector Focus
Lough-borough	Managing Value Delivery in Design	IMRC: £154k Other: £454k	Created a Spinout company (Potential to inform new build construction projects - Manchester City Council has used the research methods in their £36million schools programme)	Construction
Lough-borough	Regenerative medicine (Grand Challenge)	IMRC: £4.2m Other: £2.4m	New product developed, with £21.5m of sales to date. Leverage of £28m of follow on funding (Potentially helping the UK to capture an increased share of the regenerative medicine market – a 0.5% share of this market would be worth £650m p.a.)	Healthcare
Lough-borough	E-MEDIC	IMRC: £371k Other: £783k	Actual impacts not disclosed due to commercial sensitivity (Potential to increase market penetration – resulting in additional sales of £35-70m p.a.)	Healthcare
Lough-borough	Development of new exercise platforms (e.g. Reebok Deck, I-Play, AB Pump)	IMRC: £161k Other: £128k	New product revenues of £8.5 million to date IP Revenue to a spinout of £300,000 (Potential to support additional revenues of up to £7m)	Sports
Lough-borough	Design for Rapid (Additive) Manufacturing	IMRC: £317k Other: £264k	(Potential to reduce carbon emissions in the UK air transport sector – with carbon savings estimated at £2.2 billion p.a.)	Aerospace / Defence
Lough-borough	Business driven automation	IMRC: £702k Other: £1.1m	(Potential cost savings to the automotive sector of £100 million)	Automotive
Reading	Though Life Knowledge Information Management (Grand Challenge)	IMRC: £625k Other: In kind	Improvements in productivity and efficiency within firms (unquantified) (Potential to create competitive advantage in firms which will support increased sales)	Construction
Reading	Procurement	IMRC: £99k Other: In kind	Increase sales within collaborator firms Providing inputs into government policy on bid rigging (OFT) Informing standards on tendering and consortia – for BSI, ISO and FIDIC (Potential to reduce tendering costs in businesses – leading to estimated cost savings of £6-36 million per annum across the construction sector)	Construction
Reading	Competitiveness	IMRC: £175k Other: In kind	Informing government strategy and policy – the UKTI Export Strategy Leverage of additional research funding from overseas (Potential to support growth in construction sector exports – estimated at £5million p.a.	Construction

IMRC	Description	Funding	Summary of Actual and (Potential) Impacts	Sector Focus
UCL	Instigating a Cultural Change in New Process development	IMRC: £245k Other: Unknown	Reducing the cost of drug development by 50% New product licensed to AstraZeneca – with fees to date of £36m (Potential for £160m of additional licensing fees if product is successful, plus royalty fees of £130m p.a.) (Potential to reduce drug manufacturing costs by 10-20%) (Potential to bring about savings in drug development costs across the wider bio-pharmaceutical industry resulting in estimated cost savings of £25m p.a.)	Pharmaceuticals
UCL	Allogenic cell therapy	IMRC: £85k Other: In kind	Reducing drug development costs Improving the chances of developing a successful product Follow on TSB project (bioprocessing discovery platform for cells for therapy) with £1.8m of funding	Pharmaceuticals
UCL	Optimal process sequences	IMRC: £205k Other: In kind	Improved the purification process, assisting in bringing a new product to market License payments to date of £7m ($400m of license payments dependent on reaching future milestones) (Potential to reduce the manufacturing costs for the drug)	Pharmaceuticals
Warwick	House building as a manufacturing process	IMRC: £69k Other: In kind	£13million investment in a new company Created 90 jobs, supporting a GVA of £5.2m p.a. (Potential energy savings of £9 million p.a. resulting in carbon savings valued at £0.9m carbon p.a.)	Construction
Warwick	The management and organisation of clinical trials	IMRC: £267k Other: £391k	Informing UK clinical trials policy (Potentially contributing to safeguarding the UK clinical trials sector – worth an estimated £1.8 billion p.a.)	Healthcare
Warwick	Appropriate Product Representations for Assessment In Structured Evaluations (APPRAISE)	IMRC: £671k Other: £600k	(Potential impact due to the use of research outputs by Jaguar Land Rover. JLR has an annual R&D spend of £447m)	Automotive
Warwick	Lean manufacturing in aerospace	IMRC: £268k Other: In kind	Increased sales - growth in market share from 5% to 50% of the European composite propellers market (Potential to result in cost savings for UK aerospace companies of £60-240 million p.a.)	Aerospace / Defence

Appendix 2: Summary of Individual IMRC Reviews

Bath Innovative Design and Manufacturing Research Centre

Key Facts	
Time Period	**10 Years Total** Phase 1 (2001-2006), Phase 2 (2006-2011)
Total Value of EPSRC Grant	**£11.25m total** (Phase 1 £4m, Phase 2 £7.25m)
Other Funding *(Direct leverage of additional research funding specific to IMRC)*	**£14.4m total** of which • £4.1m[12] Research Council (non-IMRC) • £2.2m UK Public sector (non-RC) • £6.8m UK Private sector • £1.3m Overseas
Projects funded to Date	117
Current Staff	32 funded by IMRC (12 academics; 20 PDRs)
PhD Students	33 current + 25 completed to date (both phases) *(funded by IMRC grant / supervised by IMRC staff)*
IMRC journal publications	319
Patents granted	0
Key Sectors of Focus	Cross-Sectoral but with a particular focus on: Advanced Engineering, Aerospace, Automotive, Defence, Electronics, Fluid Power, Manufacturing, Marine, Medical, Mining, Packaging Machinery, Power Generation, Pharmaceutical, Rail, Renewable Energy and Sports
Current Research Themes / Specialisms	Constraint-Based Design and Optimisation (CBDO) Design Information and Knowledge (DIAK) Advanced Machining Processes and Systems (AMPS) Metrology and Assembly Systems and Technologies (MAST)
Examples of impact	• Improving industrial processes leading to increased profitability • Developing new machinery or tooling for existing machines to improve production processes and reduce cost • Reducing the amount of material used in the packaging industry leading to reduced costs and less waste sent to landfill
Examples of value added by IMRC model	• Security of funding allows research to evolve fully • Staff development • More strategic focus for research • Encourages interdisciplinary working • Are more visible and responsive to industry • Enhances international reputation • Critical mass of research • Supports both innovative blue-sky research and applied research

[12] The KIM Grand Challenge included £3.6M of additional EPSRC funding, and was led by the University of Bath. Of the £3.6M, around three-quarters was distributed across the other academic partners, and 9% to other departments at Bath.

Cambridge Institute for Manufacturing (IFM) Innovative Manufacturing Research Centre

Key Data	
Time Period	**10 Years total** Phase 1 (2001-2006); Phase 2 (2006-2011)
Total Value of EPSRC Grant	**£12.9m total** Phase 1 £5.5m; Phase 2 £7.4m
Other Funding *(Direct leverage of additional research funding specific to IMRC)*	**£12.1m total** (94% of EPSRC funding) • 70% UK private sector (£8.5m) • 14% UK public sector (£1.7m) • 8% Overseas (£0.9m) • 8% Charity (£1.0m)
Projects	86 projects funded to date Average size: £150k (EPSRC funding); £291k (All funding)
Current Staff	29 staff funded by IMRC grant
PhD Students	36 PhDs completed to date + 80 current PhD students *(funded by IMRC grant or supervised by staff involved in IMRC)*
IMRC journal publications	267
Patents granted	3
Key Sectors of Focus	Industrial Photonics, Management and Policy
Current Research Themes / Specialisms (Phase 2)	• Industrial Photonics • Technology Management • Emerging Industries • Strategy and Performance • Economics and Policy
Examples of key economic impacts	**1. Supporting business growth –** helping a company breakthrough into a new market and establish a market leading position in the growing high power fibre laser sector. Supporting turnover of £14m, and employment of 210 people in Southampton. **2. Commercialisation of research which has the potential to catalyse new product development and innovation across a range of business sectors** – development of a new laser assisted cold spray metal deposition process 3. **Helping policymakers and private sector R&D managers to develop a strategic framework for R&D activities –** through use of a technology roadmapping management tool. The IfM has undertaken over 200 roadmapping projects, and trained over 750 people to use the tools since 2005.
Key value added aspects demonstrated by the IMRC	• Institutional capacity building • Risk-taking • Staff continuity • Responsiveness to industry needs

Cranfield Innovative Manufacturing Research Centre

Key Data	
Time Period	**10 Years total** Phase 1 (2002-2006); Phase 2 (2007-2011)
Total Value of EPSRC Grant	**£16.2m total** Phase 1 £6.5m; Phase 2 £9.7m
Other Funding *(Direct leverage of additional research funding specific to IMRC)*	**£12.7m total** (78% of EPSRC funding) of which £5.6m cash + £7.1m in kind support. • 94% UK private sector (£11.9m) • 6% UK public sector (£0.73m)
Projects	90 projects funded to date Average size: £180k (EPSRC funding); £321k (All funding)
Current Staff	32 staff funded by IMRC grant
PhD Students	109 PhDs completed to date + 72 current PhD students *(funded by IMRC grant or supervised by staff involved in IMRC)*
IMRC journal publications	426
Patents granted	2
Key Sectors of Focus	Generic / cross-sectoral

Current Research Themes / Specialisms (Phase 2)	• Manufacturing Technologies
	  ○ - Precision technologies
	  ○ - Metals processing
	  ○ - Composite processing
	• Product Service Systems (helping manufacturing companies to add services to their traditional products).

Examples of key economic impacts	**1. Reducing UK government defence costs** - indicative estimate that £13 million p.a. could be saved from new cost estimation methods to improve the process of costing support and service contracts in the defence sector. **2. Helping UK defence manufacturers to win more business in global defence markets** - indicative estimate that £200 million p.a. additional business could be generated from new cost estimation methods. **3. Helping BAE Systems to win a share of the growing global market for UAVs**. A 1% share of this market would represent about £74 million per annum (based on the projected size of the market in 2020). **4. Reducing the cost of pipeline construction**. A new hybrid laser / arc welding process has the potential to reduce the cost of pipeline construction by up to £1 billion per annum. It also has the potential to transform many types of fabrication process undertaken by manufacturing companies.
Key value added aspects demonstrated by the IMRC	• More strategic focus for research • Greater responsiveness to industry needs • Continuity of research • Multi-disciplinary working • Facilitation of industry networks

Heriot-Watt Innovative Manufacturing Research Centre

Key Data	
Time Period	**10 Years total** Phase 0: 2000 - 2005 (IMRC from 2003) Phase 1: 2003 - 2008 Phase 2: 2008 - 2013
Total Value of EPSRC Grant	**£11.5m total** Phase 0 - £2.1m Phase 1 - £3.5m Phase 2 - £5.9m
Other Funding *(Direct leverage of additional research funding specific to IMRC)*	**£9.59m total** (83% of EPSRC funding) – of which • Research Councils (non-IMRC) - £5.10m • UK Public sector (non-RC) - £1.66m • UK private sector - £1.25m • Overseas - £1.58m
Projects	56 projects funded to date Average size: £215k (EPSRC funding); £433k (All funding)
Current Staff	38 staff funded by IMRC grant (21 investigators; 17 PDRs)
PhD Students	34 PhDs completed to date + 34 current PhD students *(funded by IMRC grant or supervised by staff involved in IMRC)*
IMRC journal publications	112 journal publications; 195 conference presentations
Patents granted	20 filed; 11 licensed
Key Sectors of Focus	Aerospace, automotive, retail, semiconductor electronics, machine tools, software, packaging, textiles and bio-medicine
Research Themes / Specialisms	**Digital Tools** (DT) - development of highly intuitive tools to manage information and knowledge in the design and manufacture of 3D products **Microsystems for Manufacture** (MM) – development of innovative technologies that underpin the integration and packaging of Micro-Electro-Mechanical Systems (MEMS) **Photonics-based Manufacturing** (PM) – research on technologies for industrial laser tools, optical sensing measurement, fibre delivery, novel beam-forming optics and industry-led high power laser applications.
Examples of key economic impacts	1. **Contribution towards $1billion sales across global laser market** - IMRC funding has supported Heriot-Watt maintain its position as a world leader in laser technologies. 2. **Supporting Renishaw plc as world leader in specialist measuring equipment** – multiple projects over the last 7 years generating increased sales in automotive & aerospace 3. **Groundbreaking 3D-Mintegration Grand Challenge programme** – this has generated strong potential impacts with Zeiss, National Physical Laboratory & Renishaw plc.
Key value added aspects demonstrated by the IMRC	• More strategic focus for research • Flexible and fast response to industry needs • Continuity of research – long vs. short term perspective • Multi-disciplinary working –within HW-IMRC & University • Reducing risk and increasing R&D in the private sector • Building and retaining industrial partnerships 1-2-1

Loughborough Innovative Manufacturing and Construction Research Centre

Key Data	
Time Period	**10 Years total** 1st October 2001-30th September 2011
Total Value of EPSRC Grant	**£32.0m total**
Other Funding *(Direct leverage of additional research funding specific to IMRC)*	**£34.4m total** (108% of EPSRC funding) • Research Councils, non-IMRC (£7.2m) • UK public sector, non-Research Council (£2.2m) • UK private sector (£19.0m) • Overseas (£6.0m)
Projects	214 projects funded to date
Current Staff	**145 total -** 38 Academic staff, and 107 Post-doctoral researchers
PhD Students	198 PhDs completed to date + 55 current PhD students *(funded by IMRC grant or supervised by staff involved in IMRC)*
IMCRC journal publications	469
Patents granted	5
Key Sectors of Focus	Regenerative medicine, Electronics manufacturing, Additive manufacturing, Intelligent automation, Sports technology, Sustainable manufacturing, Construction
Current Research Themes/ Specialisms	• Customised Products • Healthy & Secure Future • High Value Assets • Next Generation Technologies • Transforming Organisations
Examples of key economic impacts	**1. Informing the Build Design Process at Manchester City Council** – A method developed at the IMCRC has been used to help inform the design process for new primary schools in Manchester worth around £36 million since 2005/2006 **2. Development of a new automated cell culture system** – Total revenues of £21.5 million up to January 2011 **3. Development of a new powder-based inhaler** – A 1-2% share of this market would equate to annual revenues of £33 million-£65 million **4. Development of the Reebok Deck and i-Play** – Combined revenues of circa. £8.5 million to date **5. Reducing emissions in the aerospace sector** – Indicative estimate of £60 million in carbon savings for a single aircraft over a 30 year lifespan **6. Cost savings to the automotive sector** – Estimated cost savings of £100 million if the business driven automation techniques are applied to the engine programmes being run by Ford at any one time.
Key value added aspects demonstrated by the IMCRC	• Providing continuity to research themes • Multi-disciplinary working – both internally and externally • Enhancing existing industrial networks and supporting the development of new links with the private sector • Providing a more strategic focus for research

Reading Innovative Construction Research Centre (ICRC)

Key Facts	
Time Period	Phase 1 (2002-2007), Phase 2 (2006-2011) 9 Years total duration
Total Value of EPSRC Grant	**£6.23m total** over two phases
Other Funding *(Direct leverage of additional research funding specific to IMRC)*	**£6.7m total**, of which • £3.0m - Research Council (non-IMRC) • £3.7m - Private sector and Industry Groups
Projects funded to Date	35
Current Staff (IMRC-funded)	30 in total (12 academics, 16 PDRs, 2 support staff)
PhD Students	40 current + 31 completed from 2003 onwards *(funded by IMRC grant / supervised by IMRC staff)*
IMRC journal publications	90
Patents granted	0
Key Sectors of Focus	Construction
Current Research Themes / Specialisms	• Through-life management and innovation • Competitiveness, Productivity & Performance • Innovative Procurement
Examples of impact	• Leverage of additional research income • Inputs into a number of best practice standards on tendering and consortia – which will ultimately improve competitiveness within the construction sector • Inputs into government policy (OFT) on bid rigging - which will ultimately improve competitiveness within the construction sector • Inputs into the UKTI Export Strategy – which could potentially support an increase in UK Construction sector exports • Potentially reducing the costs of tendering within the construction sector. DTZ estimate that a 1% reduction in the cost of tendering would translate into a £6 million - £36 million cost saving per annum across the construction sector.
Examples of value added by IMRC model	• High level of industry engagement – leading to industry relevance of research • High level of engagement with policymakers • Coherent research strategy – supporting the development of critical mass and improvements in efficiency • Longevity of model – supporting long term investment in human capital • Strong governance structure – ensuring projects are high quality and of industry relevance • Grand Challenge projects supporting cross-institution working

UCL Innovative Manufacturing Research Centre

Key Data	
Time Period	Phase 1 (2002-2007), Phase 2 (2008-2012) 10 Years total duration
Total Value of EPSRC Grant	**Total: £8.9m** Phase 1 - £3.1m Phase 2 - £5.9m
Other Funding *(Direct leverage of additional research funding specific to IMRC*)	**£10.1m total**, of which £1m cash and £9.1m contributions in kind
Projects	60
Current Staff	17 total including 7 core academics, 2 admin/technical support staff and 8 PDRs
PhD Students	89 current plus 50 completed to date *(funded by IMRC grant or supervised by staff involved in IMRC)*
IMRC journal publications	270 publications
Patents granted	2
Key Sectors of Focus	Biopharmaceuticals
Current Research Themes / Specialisms (Phase 2)	• Theme 1: Micro-scale bioprocess engineering • Theme 2: Enhanced knowledge acquisition • Theme 3: Whole bioprocessing advances (disruptive technologies)
Examples of key economic impacts	• Reducing development costs for the manufacture of biopharmaceuticals – development time for CytoFab, a drug to treat sepsis, was reduced by 50% with 50% fewer resources required. • Enabling biopharmaceutical manufacturers to reach market faster – CytoFab development time was reduced by a year, increasing the potential for profits before patents expire • Reducing production costs for manufacture – more intelligent selection of cell lines can lead to the adoption of cells which are cheaper to produce
Key value added aspects demonstrated by the IMRC	• More strategic approach to research • Understanding of industry needs • Builds critical mass • Longevity of funding model supports work into research themes

Warwick Innovative Manufacturing Research Centre

Key Data	
Time Period	**10 Years total** 1st October 2001-30th September 2011
Total Value of EPSRC Grant	**£16.2m total** Phase 1 £5.4m; Phase 2 £9.9m
Other Funding *(Direct leverage of additional research funding specific to IMRC)*	**£15.7m total** (97% of EPSRC funding) • Direct leverage, AWM/ERDF for facilities (£6.3m) & EPSRC Collaborative Training Accounts and Doctoral Training Grants (£996,000) • Research Councils, non-IMRC – ESRC (£437,000) • UK public sector, non-Research Council (£431,000) • UK private sector (£7.1m) • Overseas, £451,000[13]
Projects	94 projects funded to date
Current Staff	85 total – 41 Academic staff + 44 Post-doctoral researchers
PhD Students	53 PhDs completed to date + 26 current PhD students *(funded by IMRC grant or supervised by staff involved in IMRC)*
IMRC journal publications	103
Patents granted	13
Key Sectors of Focus	• Aerospace • Automotive • Construction • Medical
Current Research Themes/ Specialisms	• Intelligent & Eco-Friendly Vehicles • Next Generation Healthcare
Examples of key economic impacts	**1. Developing Energy Efficient Housing** – estimated annual energy bill savings of £18 million **2. Helping to safeguard the future of UK clinical research** – the estimated value of R&D in the UK pharmaceutical industry is £4.5 billion per year **3. Informing R&D in the Automotive Sector** – at Jaguar Land Rover, research outputs are being used to inform the vehicle design process, which in total is worth more than £300 million per year. **4. Cost savings to the UK aerospace sector** – estimated annual savings of £60 - £240 million as a result of new lean processes developed.
Key value added aspects demonstrated by the IMRC	• Encouraging multi-disciplinary working • Removing the risks associated with responsive mode funding • Providing a more strategic focus for the management and development of research • Creation of new links with industry and developing ones already in existence

[13] Includes overseas government scholarships and self-funded doctoral students.