



Innovate UK

# The India-UK Future Manufacturing Report

Exploring joint opportunity  
for innovation and growth



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# Executive Summary

The UK and India are among the top manufacturing countries in the world with a combined manufacturing output of more than US\$500 billion. UK expertise in advanced manufacturing and its well-developed innovation programmes alongside the scale and ambitions of India's manufacturing sector present an opportunity for both countries. Greater collaboration – from joint research and development and the creation of new technologies to increased trade and investment – can deliver growth and increased productivity in the UK and India.

Advanced manufacturing can provide the underpinning technology to deliver solutions to the challenges faced by India, from access to clean, affordable and reliable energy to food security, mobility and beyond.

The UK and India have a long tradition of collaboration in science and innovation. Existing support programmes, such as Newton-Bhabha Fund, are a strong foundation for an enhanced programme of collaboration designed to deliver benefits to both nations.

The time for increasing this activity is now. The Indian government's Make in India campaign aims to secure both the investment and innovation required to create best-in-class manufacturing infrastructure, and deliver growth, productivity and jobs. The UK government's aim to drive growth and productivity through a modern industrial strategy is an opportunity to build on existing relationships between the governments, industries and academic institutions.

Between October 2016 and March 2017 Innovate UK and UK Science and Innovation Network in India carried out an exercise to:

- explore the benefits of increasing collaboration
- provide specific recommendations on themes and activities for UK-India collaboration in advanced manufacturing
- identify specific support mechanisms and programme activity

## UK-India collaboration

The Indian manufacturing sector could be worth \$1 trillion by 2025, placing it among the largest manufacturing nations in the world. The growth potential and appetite for advanced manufacturing innovation and solutions is high in sectors such as automotive, aerospace, defence and pharmaceuticals. The UK's expertise in advanced manufacturing and its innovation infrastructure can help to deliver the growth aspirations of both countries.

There already exists a wide variety of collaborative innovation in advanced manufacturing between the UK and India. The Newton-Bhabha fund, part of the UK's official development assistance, has run 6 joint competitions that have awarded more than £18 million to collaborative projects across a range of sectors and challenges.

The UK's Science and Innovation Network, the European Enterprise Network and Department for International Trade are actively supporting collaboration and trade across India. The UK High Value Manufacturing Catapult centres work with Indian and Indian-owned companies operating in the UK. There are private initiatives to foster greater collaboration, some seeking to establish joint centres for supporting innovation in manufacturing, and various forums, such as the UK India Business Council Joint Economic Trade Committee (JETCO). This is a strong foundation.

## Manufacturing sectors

There are several advanced manufacturing sectors with strong potential for increased collaboration, particularly the UK and Indian automotive and aerospace and aviation sectors. Government and industry-led initiatives in both countries are responding to the opportunity presented by the shift to electric vehicles, which will require significant investment in innovation, but offers significant economic and environmental returns.

Increased collaboration in advanced manufacturing could:

- connect Indian businesses and their suppliers into the UK manufacturing sector and its supply chains to provide economic benefits to both nations
- allow both nations to gain from new digital manufacturing technologies (Industry 4.0) by working with India's world-class IT sector
- give India access to the UK's high-quality engineering resources and networks and UK access to India's production capability
- offer UK companies and research institutions greater understanding of and access to the Indian market
- bring increased investment in research and development by Indian companies into UK companies, universities and research organisations

## Themes for collaboration

There are many areas of mutual interest to both UK and Indian manufacturers. Specific ones were identified and need to be refined, but the following list summarises some of the main emerging themes:

- digital manufacturing (Industry 4.0)
- flexible and distributed manufacturing
- light-weighting through design and use of advanced materials
- sustainable manufacturing
- robotics, automation and artificial intelligence
- additive manufacturing

Collaboration in any of these areas could improve the competitiveness and productivity of manufacturers and their supply chains and increase national productivity for both the UK and India. There are also a number of themes identified in the report that could form the basis of future Newton-Bhabha competitions.

A joint initiative could start with coordinating, as much as possible, existing activity and innovation support to avoid duplication of effort and maximise return on investment. A clear and aligned set of goals must be developed and agreed between all stakeholders. The wider potential impacts of some themes also need to be considered, for example advances in automation can increase productivity but may lead to changes in manufacturing labour and workforce skill requirements.

Wider national concerns should also be considered. Any programme would need to ensure equitable benefit from collaboration for both countries and take account of other relevant national initiatives. Consideration should also be given to competition from other countries with strong capability in high value manufacturing, such as Germany and Japan.

## Ways of collaborating

A range of innovation support could make up a wider programme that can be delivered jointly by Innovate UK, BEIS, DIT, FCO SIN and their Indian counterparts including:

- increased co-ordination and awareness of the current mechanisms to support and fund collaboration.
- a joint UK-India network, perhaps based on the UK Knowledge Transfer Network, connecting both business and academic partners in advanced manufacturing
- research and development funding competitions that provide connecting activity as well as funding – building on the success of the Newton-Bhabha fund. Competitions could be jointly funded and specific challenges identified
- support for demonstration and localisation of innovative technology, such as showcase events, which can drive both uptake and investment
- an advanced manufacturing mission programme, taking high-growth-potential UK companies and solutions-providers to India and promoting access to potential partners
- establishing more long-term collaboration and partnership models, such as a UK-India Future Manufacturing Centre or a network of centres in India, based on the UK Catapult model

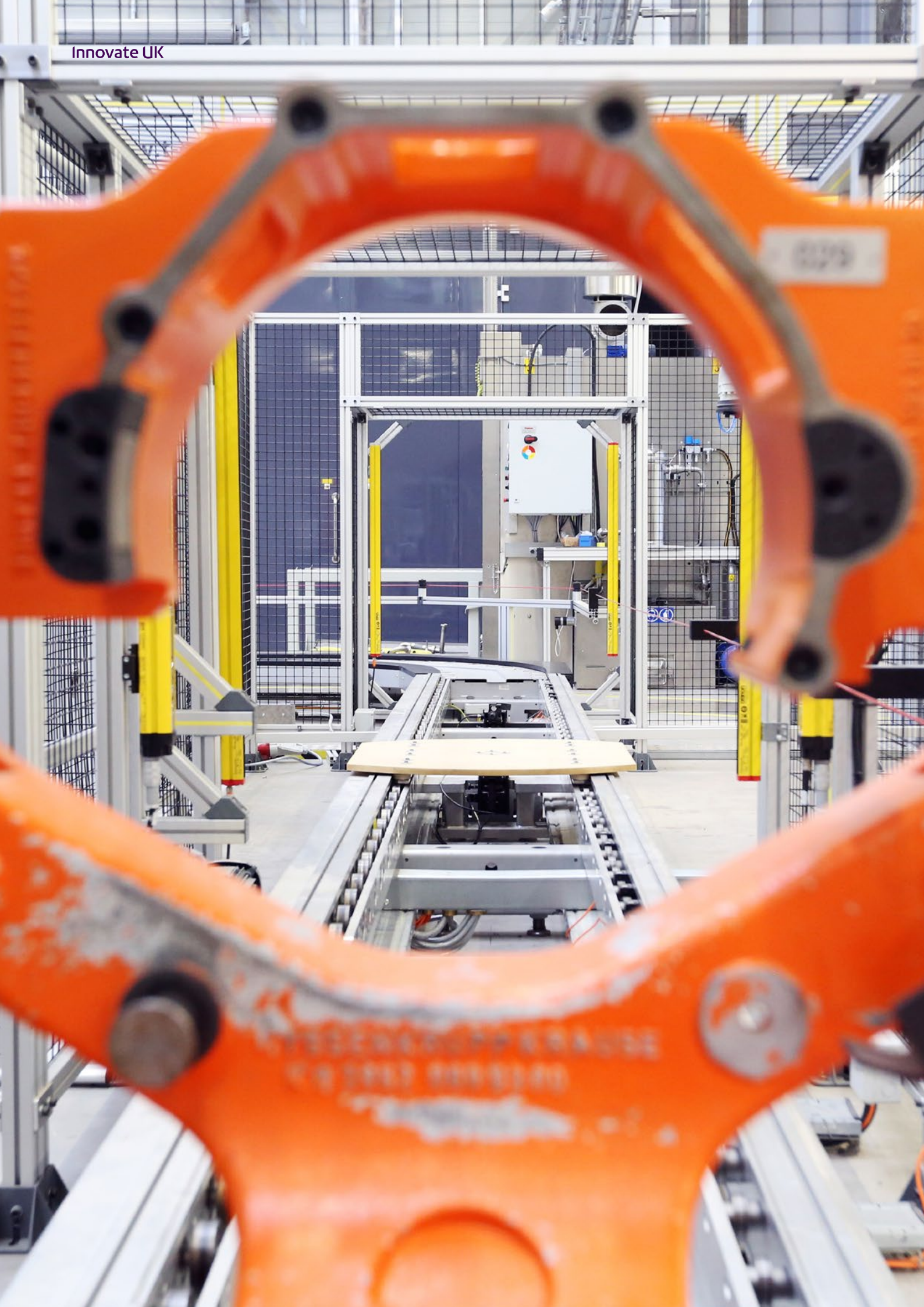
Further work is required to develop a full business case for each of these proposals and to ensure activity will deliver benefits equitably for both countries in line with their respective growth strategies.

## Next steps

The following suggestions are ways in which the ideas in this report could be developed.

- 1 Establish a UK-based steering group across Innovate UK, RCUK, BEIS, DIT, FCO SIN to consider and guide future thinking.
- 2 Organise a UK-based workshop to test the concepts outlined in this report with UK businesses and research organisations.
- 3 Investigate the business case for a wider advanced manufacturing collaborative programme against some or all the possible programme elements.
- 4 Hold a bilateral event to establish a strategic dialogue between both countries involving commercial, academic and policy makers in India and the UK.
- 5 Define possible areas for joint funding competitions in advance manufacturing for Newton-Bhabha (and beyond) using the range of themes identified in this report as a starting point.
- 6 Plan and deliver in conjunction with the Indian Department of Science and Technology a sandpit-style event to map challenges and opportunities in sustainable manufacturing.
- 7 Investigate the feasibility of and business case for 'Catapult-like' centres in India.





# Introduction

In October 2016 Science and Innovation Network India and Innovate UK agreed to jointly carry out research into the opportunity for greater collaboration between the UK and India in future manufacturing.

The goal was to map the key barriers, challenges and status of UK-India joint R&D and government support for manufacturing, explore funding models to support future collaborations between UK and India and identify themes of interest to manufacturers in both countries. The final outcome would include a series of recommendations towards a joint programme of innovation support.

Between October 2016 and April 2017 a series of workshops, visits and interviews were undertaken in both countries exploring future manufacturing innovation and collaboration. This report summarises that work and makes a number of suggestions for next steps.



# Manufacturing in the UK and India

India and the UK are among the top 10 manufacturing countries in the world. India is 6th with a manufacturing output of \$290 billion and the UK 9th with \$247 billion. Between them, they accounted for 6% of world manufacturing output in 2014 [1].

The UK economy is strong in high value and advanced manufacturing. Manufacturing underpins sectors such as aerospace, automotive, energy, transport and process industries. It provides an estimated 2.7 million direct jobs and 44% of exports [2].

Indian manufacturing could be worth US\$1 trillion by 2025, rivalling China and the US as one of the world's largest manufacturing sectors [3]. India's economy grew by 7.3% in 2015-16, and this rate of growth is expected to continue for a third year in succession in 2016-17 [4]. The government economic survey (2015-16) [5] states that government's commitment to carry the reform process forward could raise the economy's growth to 8% in coming years.

Manufacturing is pivotal to the economy attaining and sustaining this ambitious target. India also needs to export more to reduce its trade deficit and needs to create one million jobs a month to support a growing population.

Strong collaboration on innovation in manufacturing has the potential to support economic growth in both the UK and India. There are strong links between the UK and India – both culturally and in trade and investment. India's ambitious plans for growth represent a significant opportunity for trade and investment on both sides.



## Trade

India imported US\$356.7 billion of goods from around the globe in 2016, up by 33.9% since 2009. Its top 10 imports accounted for almost three-quarters (74.3%) of the overall value of its product purchases from other countries. India purchased 58.2% of its imports by value in 2016 from other Asian countries, 17.5% from Europe, 7.4% from North America and 7.3% from Africa [6].

The UK exported goods worth £6.35 billion to India and services valued at £2.24 billion in 2014 [7].

## Investment

India is the 3rd largest investor in the UK based on Department for International Trade metrics, and the country's Tata Group is Britain's largest single manufacturing employer. There are more than 800 Indian-owned businesses in the UK employing more than 110,000 people. Investment ranges across sectors including manufacturing, healthcare, agri-tech and food and drink [8].

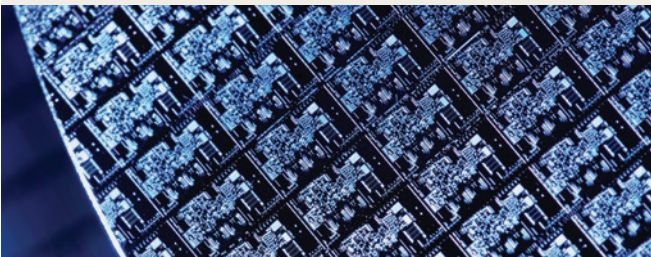
The UK is the largest G20 investor in India and the third largest investor in India overall. The combined revenue for UK companies in India is more than US\$54 billion, and almost 10% of all foreign direct investment is from the UK [9]. Around 535 UK businesses currently operate in India, in sectors ranging from retail to creative industries.

The Department for International Trade (DIT) has increased its business wins performance in India to over £2.7 billion in 2015-16. Relative trade performance is also up, with the UK outperforming Germany, France and Italy for 2 consecutive years based on market share of India's imports.

DIT has export campaigns with India across a range of markets and sectors, including: automotive, chemicals, renewables, healthcare, construction and technology. Advanced manufacturing has recently been given priority campaign status for trade.

## Success Story

### Precision Varionic International and Badve Engineering



UK-based designer and manufacturer of automotive position sensors and throttle pedals Precision Varionic International (PVI) signed a joint venture with leading Indian auto component manufacturer Badve Engineering Ltd at the November 2016 India-UK Tech Summit in new Delhi.

PVI produces a range of innovative graphene-based sensors that will improve durability and performance and lower costs in the next generation of Badve products.

PVI expects to make and supply more than 3 million sensors a year for Badve.

Other wider benefits of the collaboration include support for developing and validating new sensor products for the Indian market and access to manufacturing facilities and local networks in India.



# Innovation support

There is a wide range of support for innovation in manufacturing in both the UK and India.

## Innovation in the UK

The UK has a well-developed and co-ordinated network of agencies that support manufacturing innovation, including Innovate UK, Catapult centres, the Office for Low Emission Vehicles, the Advanced Propulsion Centre, the Centre for Connected and Autonomous Vehicles, the Aerospace Technology Institute and the research councils. Innovative businesses are used to working with each other and with academic researchers to develop new research and technologies into commercial products and services.

Manufacturing innovation is strong in the UK, with 69% of UK research and development funded directly by industry in the manufacturing sector. Of the top 2000 research and development spending firms in the world, 484 are in sectors with high dependence on manufacturing and have manufacturing presence in the UK [10].

UK government innovation support for manufacturing includes:

- Innovate UK manufacturing and materials programme, which runs 2 broad innovation funding competitions a year
- the High Value Manufacturing Catapult, with 7 centres across the UK, providing companies with access to critical facilities, equipment and expertise
- non-Catapult investments, for example the Royce Institute and National Graphene Institute
- around £500m invested by Engineering and Physical Sciences Research Council (EPSRC) and Biotechnology and Biological Sciences Research Council in academic manufacturing research to date
- EPSRC centres for innovative manufacturing, hubs and centres for doctoral training

### Innovate UK

Innovate UK supports companies and partner organisations to find and drive the science and technology innovations that will grow the UK economy to increase productivity, create new jobs and exports and keep the UK globally competitive. Since 2007, it has invested more than £1.5 billion in innovation, matched by a further £1.5 billion in partner and business funding [11].

Innovate UK's priorities in the UK manufacturing and materials sector are:

- using digital technologies in new ways to increase productivity, systems flexibility and resource efficiency
- supporting manufacturing readiness at scale
- supporting automotive and aerospace research
- early stage manufacturing and materials concepts
- increasing resource efficiency and flexibility of manufacturing and materials processes for greater resilience to changing supply and demand conditions

## Catapults

Innovate UK has built up a network of Catapult centres [12]. These independent technology and innovation centres bridge the gap between universities and businesses. They help businesses to undertake late-stage research and development and commercialise traditional academic research.

The High Value Manufacturing Catapult has 7 centres across the UK:

- **Advanced Forming Research Centre:** specialises in forming and forging technologies to support the design and manufacture of products across a range of sectors
- **Advanced Manufacturing Research Centre:** with Boeing focuses on advanced machining and materials research for high-value manufacturing sectors
- **Centre for Process Innovation:** uses applied knowledge and facilities to support companies to develop, prove, prototype and scale up new products and processes
- **Manufacturing Technology Centre:** specialises in manufacturing technologies and processes that are particularly important to the high value manufacturing sector
- **National Composites Centre:** aims to be the world-leading centre of excellence and innovation in composite technology
- **Nuclear AMRC:** uses its expertise and facilities to enhance the capabilities and competitiveness of the UK civil nuclear industry
- **Warwick Manufacturing Group:** focuses on technology challenges of low carbon mobility in aerospace, automotive, rail, marine and other sectors

## Automotive

Automotive is a key manufacturing sector in the UK. Innovate UK, the Office for Low Emission Vehicles (OLEV), Department for Transport (DfT), Department for Business, Energy and Industrial Strategy (BEIS) and the Engineering and Physical Sciences Research Council invest in business-led low carbon vehicle innovation from research through to proven concepts that are ready for industrialisation.

Innovate UK is an innovation partner for the Advanced Propulsion Centre (APC), formed in 2013 as a £1 billion, 10-year commitment between government and the automotive industry to position the UK as a centre of excellence for low-carbon propulsion development and production [13].

Innovate UK also works with the Centre for Connected and Autonomous Vehicles (CCAV) to drive autonomous vehicle research and development, industry and use in the UK [14].

The UK government's £1 billion Industrial Strategy Challenge Fund (ISCF) includes the £248 million Faraday Battery Challenge to drive innovation in the electric vehicle battery supply chain and grid management. It is one of the first wave of ISCF programmes.

## Performance and location of UK HVM Catapult centres



**1** Advanced Forming Research Centre (AFRC), University of Strathclyde

**2** Centre for Process Innovation (CPI), Redcar

**3** The Nuclear Advanced Manufacturing Research Centre (Nuclear AMRC), Rotherham

**4** Advanced Manufacturing Research Centre (AMRC), Rotherham

**5** Manufacturing Technology Centre (MTC), Coventry

**6** WMG Catapult, University of Warwick

**7** National Composites Centre (NCC), Bristol

## Aerospace and aviation

The Aerospace Technology Institute (ATI) aims to strengthen and grow the UK aerospace sector through investment in new technologies and capabilities. Its project portfolio, including private sector investment, is set to grow to £2 billion by 2020 [15].

It aims to:

- develop ambitious programmes on integrated complex technologies for future turbo-fan engines, wings and advanced aircraft systems
- initiate major cross-cutting projects to plug gaps and master transformational technologies. These include high-value design, the digital economy, additive manufacturing and through-life services
- strengthen ties with aerospace companies and research organisations in the UK and abroad

## Innovation in India

There is no direct equivalent to Innovate UK or the Catapult centres in India. However, a wide range of support mechanisms do exist, and there has been a move to align India's research base with major technology and societal challenges and to translate that research into viable commercial activity. Large government initiatives such as Make in India and IMPRINT indicate a desire within India for a more cohesive approach to innovation.

The flagship Make in India initiative aims to achieve an annual growth rate of 12-14% in manufacturing. The government wants manufacturing's contribution to GDP to grow to 25-30% and for the sector to create up to 90 million domestic jobs by 2025 [16].

Make in India is a national programme designed to increase investment, foster innovation, enhance skill development, protect intellectual property and build best-in-class manufacturing infrastructure in the country.

Its main aim is to attract investments from across the globe and strengthen India's manufacturing sector. The focus of the Make in India programme is on 25 sectors including:

- automobiles
- aviation
- chemicals
- IT and business process management
- pharmaceuticals
- construction
- defence manufacturing
- electrical machinery
- food processing
- textiles and garments
- ports
- leather
- media and entertainment
- wellness
- mining
- tourism and hospitality
- railways
- automobile components
- renewable energy
- biotechnology
- space
- thermal power
- roads and highways
- electronics systems

India has also launched Startup India, a campaign to establish and nurture 10,000 start-ups [17].

## Research base

India's research base is complex and has been described as rigid: there are many types of institution dedicated to research and development that are funded by government. Advance manufacturing and related areas are researched and taught extensively across many of these institutions, which include:

- Indian Institute of Science (IISc), Indian Institutes of Science Education and Research and Tata Institute of Fundamental Research focused on research activity
- Defence Research and Development Organisation (DRDO) Labs focused on development activities for defence technologies
- universities focused mainly on higher education, but with an increasing focus on supporting and encouraging entrepreneurship and spin-outs
- the Indian Institutes of Technology (IIT) network of 23 institutions spread across India
- the National Institute of Advanced Studies (NIAS) providing both an education and research base and with strong links with UK institutions. NIAS is the Indian partner in the joint endeavour with the Institute of Manufacturing in Cambridge, which organised the joint workshop on manufacturing referenced later in the report
- the Council of Scientific and Industrial Research (CSIR), established in 1942, an autonomous body and the largest research and development organisation in India. It runs 37 laboratories and 39 field stations across India
- the Bhabha Atomic Research Centre (BARC), a multi-disciplinary research centre with extensive infrastructure for advanced research and development covering the entire spectrum of nuclear science, engineering and related areas
- the Indian Space Research Organisation, set up by the Department of Space and located in Bangalore, the national space agency of India

Various Indian government departments, both individually and jointly, provide grant-based funding with the aim of supporting business-led research and development, though it is targeted at academic partners.

The following three examples are specific support mechanisms funded by government that support advance manufacturing innovation.

**Uccharat Avishkar Yojana (UAY)** – run by the Ministry of Human Resource Development (MHRD) and aims to improve the competitive edge of industry-sponsored, outcome-orientated academic research projects. The funding model is split 50% by MHRD, 25% by the relevant ministry and 25% by the partnering industry/business.

A total of 92 projects worth around £30 million have been approved for funding at various IITs and IISc under the UAY scheme. IIT Madras secured funding for 25 out of a total 40 projects across various industrial sectors including pharmaceutical manufacture and automotive.

**IMPacting Research Innovation and Technology (IMPRINT)** – launched in 2015 by Prime Minister Modi with the aim of aligning India's extensive research base to the nation's structural challenges in a more holistic fashion [18].

It is creating a more coherent mechanism for networking and knowledge sharing, fostering a more open approach to innovation. The programme brings together 17 research institutions under 10 domains with a single objective to accelerate research and innovation. In some respects, the IMPRINT programme looks to solve the same challenges that led the UK to create Technology Strategy Board (now Innovate UK) and the Catapult network.



**Central Manufacturing Technology Institute (CMTI)** – founded by the government of India, with technical support from Czechoslovakia, in 1963. It is an autonomous initiative funded by the Ministry of Commerce and Industry. The large facility is in Bangalore and exists to support innovation in manufacturing technology; particularly to develop and assimilate new technologies into the Indian manufacturing sector [19].

Current focus areas for the institute include:

- digital design and product lifecycle management
- precision engineering
- rapid prototyping
- mechatronics
- nanotechnology

The centre undertakes development projects for a wide range of manufacturing businesses, including SMEs.

### Collaboration on research and development

Indian manufacturing companies do collaborate on innovation and research and development, though collaboration with academic institutions and research organisations does not appear to be as extensive as in the UK. Recent government programmes and centres do promote collaborative approaches, as do requirements for companies to spend a certain proportion of revenue on corporate social responsibility, which can include research and development.

The following are examples of large Indian manufacturing businesses' individual approach to innovation and collaboration. Information was drawn from a series of site visits and meetings conducted by Innovate UK, between October 2016 and February 2017.

- **Tata** collaborates extensively world-wide with academic institutions and other research organisations. Current initiatives include those with Harvard in the US on robotics, Yale in the US on microbiology and IIT Madras on graphene. There are active collaborations with Cambridge University and Warwick Manufacturing Group (both Tata Motors and Tata Steel) and IIT Kharagpur. A collaboration with Imperial College London is due to start in 2017.

- **Bharat Forge** in Pune is a multinational company involved in manufacturing across many sectors, including automotive, power, oil and gas and aerospace. It owns and collaborates with businesses in Germany, Sweden, US and UK. It takes a global approach to innovation and research and development and has a continuous 5% sales investment in training and research and development (over 500 research and development staff). It is exploring establishment of a technology centre in the UK and always interested in joint ventures.

Current innovation focus includes closed-loop approaches, LEAN, industry 4.0 and increasing levels of automation.

It works with Fraunhofer, The Welding Institute in Cambridge, University of Sheffield, AMRC (very positive about the High Value Manufacturing Catapult and trying to do something similar with TWI) across all sorts of areas. For example, dissimilar material welding, advanced manufacturing, machine vision inspection, electron beam welding, additive manufacturing, 5-7 axis milling for prototype development and validation. Its future focus will be on composites.

- **Unilever** (Hindustan Unilever Ltd. In India) has one of its 6 major international research and development centres based in Bangalore. It collaborates on innovation projects across the global group and with partner companies.

Key areas of interest for the Indian market include provision of clean water, sanitation, personal healthcare, packaging and prevention of food waste.







# UK and India working together

Indian and UK business, research and government communities are working with each other and demonstrating a strong interest in building on that collaboration.

Companies such as Rolls Royce, Renishaw, Unilever, Tata, Mahindra, Bharat Forge, Aditya Birla and Varroc are working in areas such as the development of supply chains, technology transfer and overseas investment in both countries. For example, Bharat Forge has become a member of both the Manufacturing Technology Centre and Advanced Manufacturing Research Centre. It has also looked at commercial collaborations in areas such as low emission vehicles, composite development and even the establishment of a European technology centre in the UK.

Academics from universities such as Cranfield, Cambridge and Edinburgh have developed links and projects for technology transfer with Indian counterparts and companies – highlighted by the strong academic delegation at the 2016 Indo-UK Tech Summit.

At a UK government level, the Department for International Trade, the Science and Innovation Network, the department for Business, Energy and Industrial Strategy, Innovate UK and the High Value Manufacturing Catapult are working more closely to bring together policy and operational delivery of UK-India manufacturing collaborations. This has included joint workshops held at the National Institute of Advanced Studies (October 2016) and joint programmes at the Tech Summit with the Confederation of Indian Industries and the National Institute for Transforming India, (NITI ) Aayog, (November 2016).

Other countries, such as Germany (Fraunhofer have signed an agreement as a technology resource partner for Make in India) and Japan, are establishing agencies in India to further manufacturing collaboration.

There is already a strong foundation of collaboration between the UK and India in research and innovation. Since 2008, more than £150 million of funding has been committed to joint programmes through many individual initiatives across public and private sectors.

## Success Story Oxitec



Oxfordshire-based Oxitec developed a genetically engineered version of *Aedes aegypti* – a wild mosquito known to transmit dengue fever, yellow fever and the viral disease, chikungunya.

Oxitec's work has been supported over a number of years by Innovate UK, including through a Newton Bhabha award of £218,598 towards a collaborative research and development programme in India to control and effectively eradicate the mosquito from 2 rural hamlets. More than 725,000 people die each year following a mosquito bite.

Oxitec's state-of-the-art production unit opened in Oxfordshire in 2017 and can produce 1 billion mosquito eggs. It is expected to create 75 new jobs. The eggs will be shipped to various affected locations across the world, where they will be reared on and then released into the environment.



## Newton-Bhabha Fund

The Newton Bhabha Fund is one of the leading investors in UK-India collaborative research and development. It supports innovative solutions to the economic development and social challenges faced in India. Newton-Bhabha is part of the UK's wider £375 million Newton Fund for collaboration with various countries. In India, the fund is worth £50 million over five years. It focuses on three priority areas:

- future cities
- public health and well-being
- the energy-food-water nexus

Advanced manufacturing and big data are seen as two key areas that can deliver solutions.

Innovate UK is a delivery partner in the UK, and there are two main partners in the Government of India, the Department of Science and Technology and the Department of Biotechnology.

To date, Innovate UK has delivered 6 competitions via Newton-Bhabha, 4 with the Department of Science and Technology (DST) as the funding partner and 2 with the Department of Biotechnology (DBT) (see panel).

The competition scopes are primarily driven by the Government of India, but reflect challenges/areas where UK business expertise has been identified. The scopes of the DST calls are generally broader, for example clean technology; whereas the scope of the DBT call was more focused – a defined challenge of reducing India's post-harvest agri-food production loss (estimated at 40%).

A state-level competition – reflecting India's federal governance – is also under consideration and on-going activity to identify a suitable partner is underway.

The more general DST competitions encourage business-to-business collaborative research and development projects, and research organisations can also be involved as collaborative partners. The DBT competitions have focused explicitly on the translation of research, and either businesses or research organisations could be the project lead on the UK side. Either way, both a UK business and research organisation must be involved.

Like-for-like funding from both the Department of Science and Technology and the Department of Biotechnology for all activity

indicates a demand for industry-led innovation programmes run in partnership with the UK. Furthermore, the fund has developed the collaborative relationship with India significantly.

It is still early for in-depth measuring of progress and results for Newton-Bhabha projects – many have not yet started. There is a mix of UK partners who have worked with their Indian partners before and those that have not.

### Views of Newton-Bhabha participants

During February 2017, a series of interviews were conducted with UK companies participating in Newton-Bhabha projects. These identified a number of areas where support beyond provision of R&D funding is important for success:

- **partner identification** – introductions and other forms of networking events, both physical and on-line, can ease the development of strong collaborative partnerships
- **project development** – on-going support to assist partners between project approval and project start has been identified by applicants as an area where additional support could improve outcomes. For example, funding and other local logistical support for physical meetings between project partners. The need for each project to have a collaboration agreement signed off by all project partners (UK and India) before a project can commence is a time-consuming process
- **market knowledge** – India is not a single national market and there are marked differences between states, including language, cultural practices and preferences. Different regions have different industry clusters, legislation and market drivers. Access to local knowledge to allow for appropriate project planning is felt to be beneficial, and, though this is provided by local partners, more formal support to UK companies in early stages to better understand local conditions, business practices and to facilitate networking would be beneficial

### A SUMMARY TABLE OF INNOVATE UK'S NEWTON-BHABHA COMPETITIONS

Call title	Focus	Partners	Budgets	Results
<b>Collaborative industrial R&amp;D, Round 1</b>	affordable healthcare, cleantech, energy	DST	£1 million	1 project awarded, kicked-off in May 16
<b>Collaborative industrial R&amp;D, Round 2</b>	affordable healthcare, cleantech, energy	DST	£1.5 million	4 awards, 2 of which live since May-June 16
<b>Collaborative industrial R&amp;D, Round 3</b>	affordable healthcare, clean technology, use of ICT to provide solutions to societal challenges	DST and MeitY	£2.5million	5 awards, 2 of which live since January-February 17
<b>India-UK Research and Innovation Bridges</b>	post-farm gate agri-food challenges related to processing, packaging and distribution	DBT and RCUK	£4 million	7 awards, 5 of which live in February-March 17
<b>Technology solutions for society in India</b>	affordable healthcare, cleantech, esdm solutions for societal challenges	DST and MeitY	£1.6 million	CLOSED – pending award
<b>Bio-chemical solutions for industrial waste</b>	industrial waste streams	DBT and BBSRC	£8million	July 2017

## High Value Manufacturing Catapult

The UK's High Value Manufacturing Catapult is strengthening its relationship with India.

The Catapult's Warwick Manufacturing Group (WMG) has a longstanding relationship with India; from collaborating with the Confederation of Indian Industry to developing a programme of training and internships for Indian companies. It is helping to solve the talent crunch, and assisting in the Indian government's initiative to increase the number of Indian Institutes of Technology (IIT), including a strategic partnership with the IIT at Bhubaneswar, Odisha. The current chair of WMG, Lord Bhattacharya, has driven collaboration with India.

The Advanced Forming Research Centre (AFRC) is holding discussions with Bharat Forge about potential membership and projects. Two AFRC researchers won a travel fund to visit facilities and researchers in India in 2014; and the Indian Machine Tool Manufacturers' Association brought a delegation of managing directors/chief executives/chief technology officers to visit research and development institutes including the AFRC in summer 2017.

## UK-India biotechnology projects

Innovate UK and Research Councils UK have worked with the Indian Department of Biotechnology (DBT) on activity to turn scientific excellence into economic impact via the £10 million Research and Innovation Bridges programme – bringing together business and researchers from both countries to find novel and innovative solutions to the numerous agri-food challenges India faces.

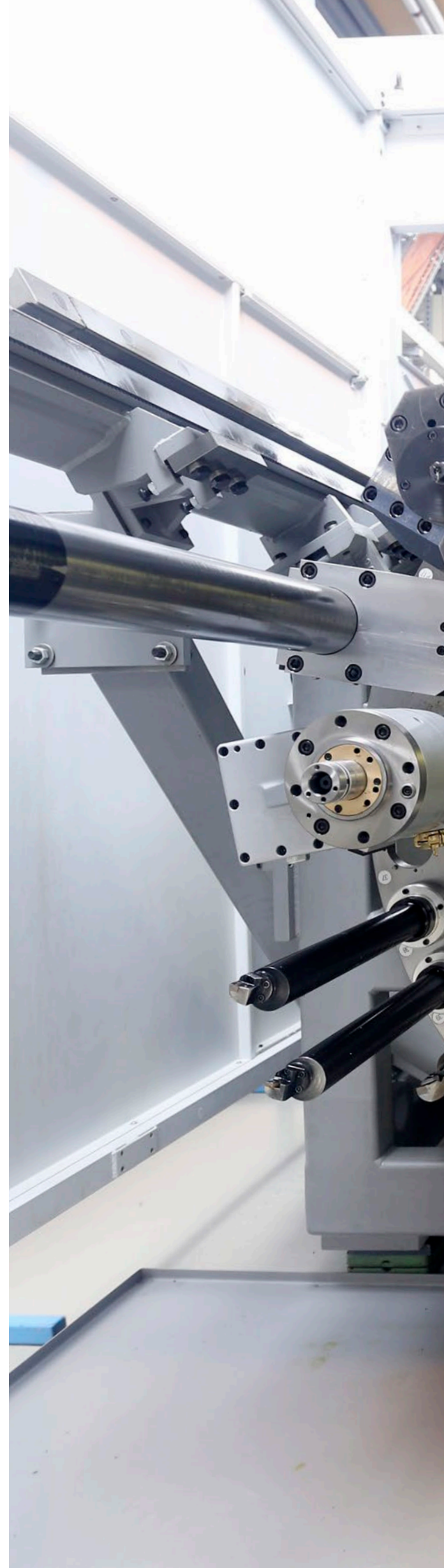
The Biotechnology and Biological Sciences Research Council and DBT have jointly funded 7 projects aimed at developing new and improved crops that have a high resistance to the effects of climate change and deliver high yield for low inputs.

## JETCO

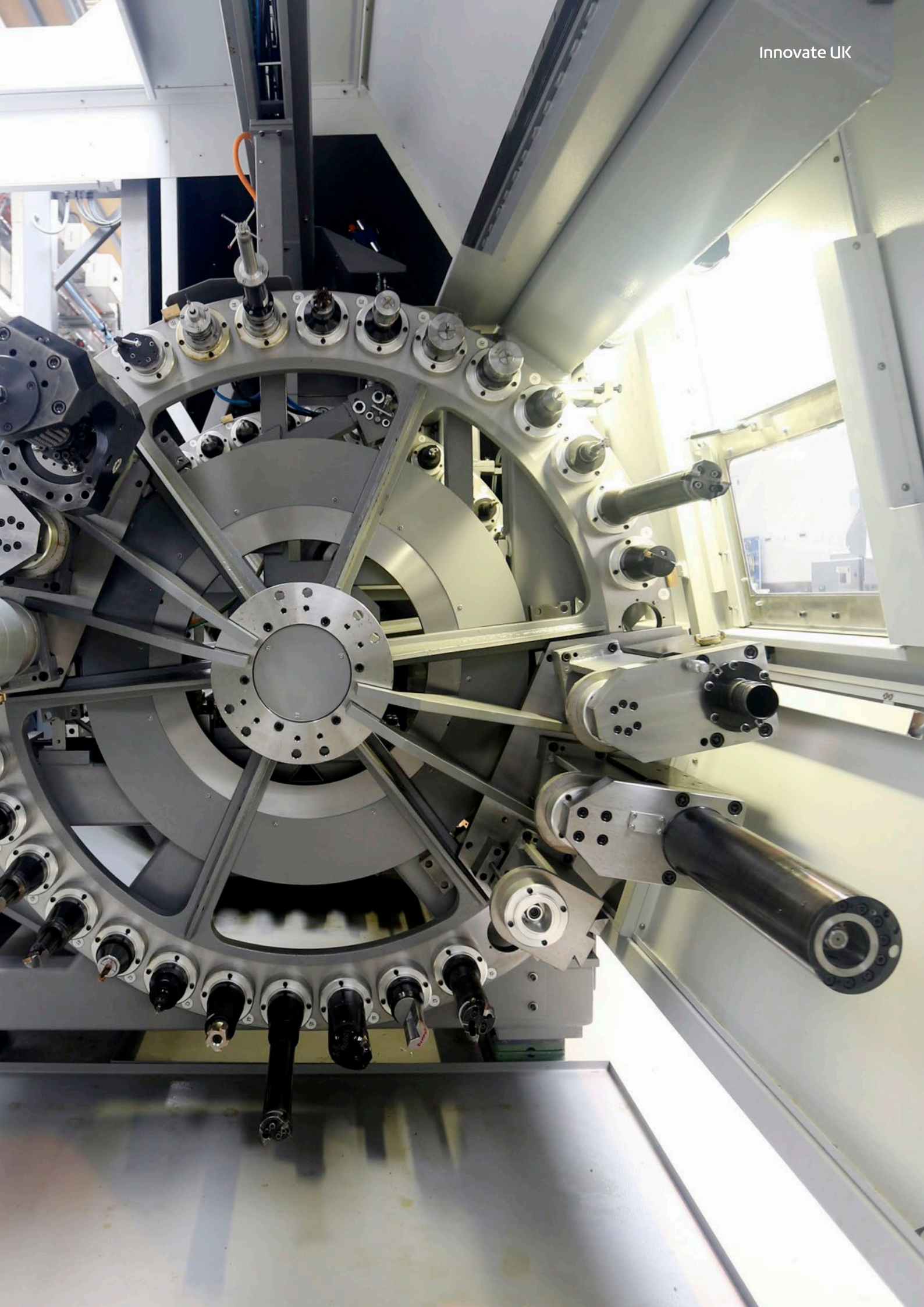
The Joint Economic Trade Committee (JETCO) exists to promote government-to-government negotiations that address market liberalisation and market access. The UK India Business Council feeds the views of the UK business community into this process, which aims to help UK companies to improve their links and develop new partnerships with Indian business and decision-makers.



THE NEWTON BHABHA FUND IS WORTH **£50 MILLION** OVER 5 YEARS, FOCUSING ON 3 PRIORITY AREAS: FUTURE CITIES, PUBLIC HEALTH AND THE ENERGY-FOOD-WATER NEXUS









# Potential innovation in advanced manufacturing

Manufacturing themes for a potential support program have been identified based on feedback from a variety of sources, including:

- interviews conducted with Indian companies between October 2016 and March 2017
- workshops held in India between October 2016 and March 2017 (in part during the DIT manufacturing mission from the 2016 Tech Summit)
- manufacturing workshops held in the UK in April 2017 to support the development of Industrial Strategy Challenge Fund bids in manufacturing and materials
- results of an Indian chief technology officers mission to the UK led by the Science and Innovation Network (SIN) and (then) UKTI in late 2015 to explore areas of interest for collaboration with the UK High Value Manufacturing Catapult

## The Indian perspective

Indian companies interviewed between October 2016 and February 2017 said they would like to collaborate with UK companies in many areas including refrigeration and cold chain approaches, lightweighting, digital manufacturing and supply chains, automation, waste treatment and pollution control, energy generation and management, food security, composites, electric vehicles, batteries and battery management, sustainable packaging, nanomanufacturing and additive manufacturing (see appendix 1).

A roundtable meeting convened by NIAS and the Institute for Manufacturing in October 2016 brought together key stakeholders from both the UK and India to discuss and identify the challenges for the Indian manufacturing sector and discuss potential solutions (see appendix 2). Challenges identified included:

- developing a product innovation culture
- identifying high-end talent
- scaling up prototypes and pilots to full production
- product lifecycle engineering including design for manufacture, serviceability, better end-of-life performance, cloud-based digital platforms, process optimisation and supply chain management
- use of advanced materials, especially for aerospace, medical devices, additive manufacturing and 2D materials
- development and adoption of feeder technologies such as nanofabrication, metrology and additive manufacturing
- introducing smart and distributed manufacturing including digital approaches and supply chain improvements driven by sensing, big data and analytics
- standards for production and testing
- introducing sustainable manufacturing

## Chief technology officers visit UK

In late October 2015 SIN and UKTI led a mission of chief technology officers from Indian companies to the UK. Delegates identified a wide range of research, commercial opportunities, and themes for collaboration. These ranged from application of Internet of Things in advanced manufacturing to additive manufacturing, nanomaterials, use of sensors, battery technologies and sustainable supply networks. There is an appetite within Indian manufacturing to work with UK Catapults across a wide variety of themes.

Further themes for collaborative activity were identified at workshops held at the TechSummit event in November 2016. They included:

- taking prototypes to market (good on ideation, more challenging to take to scale)
- manufacturing readiness
- automation – concern in Indian manufacturing about rising wage costs and, in some cases outdated (proven equipment), so retrofit also of interest. Systems to improve occupational health and safety of workers and optimise manual labour
- digital manufacturing (for productivity, labour and non-labour)
- frugal innovation for manufacturing
- automotive emissions – the move from EURO4 emissions standard to EURO6
- inclusive manufacturing – technology to reduce the cost to establish small-scale (high value) manufacturing operations, especially in rural India
- distributed manufacturing (micro manufacturing for rural India, for example additive manufacturing approaches or use of local materials)
- reducing energy, water and material footprint of manufacturing (through design and digital approaches)
- design and manufacture of affordable medical devices

## The UK perspective

Key figures from the UK manufacturing sector, academia and government came together in April 2017 for a series of workshops that aimed to identify challenges and opportunities to support innovation and drive productivity across high value manufacturing (see appendix 3).

The main themes and challenges to come out of the workshops included:

- improving skills in areas such as digital, robotics, automation and artificial intelligence
- industrial internet
- digital manufacturing
- new business models including 'an Uber model', distributed manufacturing, flexible manufacturing
- the circular economy
- global opportunities
- advanced maintenance, metrology and sensors
- additive manufacturing
- system and product design
- energy supply and efficiency
- bio-industry
- lightweighting

A number of themes have received previous funding through Innovate UK competitions complying with rules on the UK's official development assistance. These have focused on sustainable manufacturing and promoting wider environmental and social benefits, and include:

- design and manufacture of sustainable and innovative products that include cleaner processes, reduced carbon and less waste
- design of products and processes for end-of-life value and through-life engineering
- material reduction or replacement: reducing the quantity of materials used in the manufacture of a product (lightweighting) or conversion to alternative renewable or more sustainable raw materials
- input quality – technology to improve management of quality variation in raw materials
- recovering valuable materials from industrial waste
- industrial symbiosis – conversion of waste to raw material between and within manufacturing operations
- innovative heat or energy management or input in production
- moving from batch process to continuous process
- innovation in production measurement, analysis and process control to deliver resource efficiency manufacturing
- net-shape or near-net-shape manufacturing processes

## Scope for collaboration

Several sectors offer scope for innovation collaboration between India and the UK and are of particular relevance to the UK's expertise in advanced manufacturing.

### Automotive

India is the 6th largest producer in the world with an average annual production of 24 million vehicles in 2016, of which 3.64 million are exported. It is the 5th largest passenger vehicle and commercial vehicle market. In addition to internal combustion engine vehicles, six million-plus hybrid and electric vehicles are expected to be sold annually by 2020 [20]. The Indian government has committed to transitioning from the current EURO4 emissions standards to EURO6.

### Automotive supply chain

The Indian auto component industry is valued at around US\$39 billion (2015-16) and contributes 2.3% to India's gross domestic product. The sector grew 14% a year between 2006 and 2016. During the same period exports increased from US\$3.2 billion to US\$10.81 billion. Auto components are 4% of India's exports [20].

### Aerospace and aviation

India is the 9th largest civil aviation market and had passenger traffic of 224 million during 2016. India is projected to be the third largest aviation market by 2020 with a combined fleet across Indian carriers of 800 aircraft. Military aircraft procurement stood at around Rs 15,000 Cr between 2014 and 2017, and there is a significant order backlog for commercial aircraft [21]. There is a long-standing history of collaboration between the Indian and UK aerospace sectors, particularly for military aircraft.

### Biotechnology

India is among the top 12 biotech economies in the world and ranks third in the Asia Pacific. It has the second highest number of United States Food and Drug Administration-approved plants outside the US. The sector has grown from US\$1.1 billion in 2005 to US\$7 billion in 2015 and is expected to reach US\$11.6 billion in 2017 and US\$100 billion by 2025 [22]. Government support for the sector is underpinned by the creation of the Biotechnology Industry Research Assistance Council (BIRAC) and the Department of Biotechnology (DBT)

### Chemicals

India is the 7th largest producer of chemicals worldwide and third largest producer in Asia by output, the total market value is estimated at approximately US\$139 billion. Total production of major chemicals including petrochemicals was 23.9 million tons during 2015-16 while production of polymers stood at around 9 million tons [23].

### Pharmaceuticals

India is the 3rd largest pharmaceuticals market in the world. Industry revenues are expected to expand at an annual growth rate of 12.1% during 2012-20 to reach US\$45 billion. Total exports of drugs and pharmaceuticals for 2013-14 were US\$15 billion, an annual growth rate of 2.5% over the corresponding period of previous years [24].

India accounts for about 3.6% of the global pharma industry by value but this equates to 10% by volume. The Government of India introduced the Pharma Vision 2020 programme aimed at making India a global leader in end-to-end drug manufacture. Approval time for new facilities has been reduced to boost investability.

# Benefits of collaboration

There are many opportunities to increase the growth and productivity of the UK and Indian advanced manufacturing sectors through greater collaboration.

Integrating Indian businesses and their suppliers into the UK manufacturing sector can provide economic benefits to both nations. There are opportunities to increase labour and resource productivity and to develop new technologies and supply chains, for example for the manufacture of electric vehicles or flexible electronic products.

Greater access to India's world-class IT capabilities can enhance manufacturing through the development and adoption of new digital technologies both in the UK and India. Digital approaches can also be developed and implemented to drive productivity gains in both existing and developing supply chains between UK and India.

There is already a wide program of collaborative activity. Any increased programme of activity will need to take account of existing relationships and mechanisms and should seek to ensure maximum return on investment, in part by avoiding duplication of effort and by building on existing foundations.



THERE ARE MORE THAN **800**  
**INDIAN-OWNED BUSINESSES**  
**IN THE UK** EMPLOYING MORE  
THAN **110,000** PEOPLE.

## Mutually beneficial partnerships

The UK's high-quality research and development capability in manufacturing as well as its high value production capacity can be made available to the Indian manufacturing sector, and the extensive scale of India's production as well as its growing markets can be accessed by the UK in mutually beneficial partnerships.

A greater understanding of the Indian market and manufacturing sector would allow UK companies to:

- increase export sales
- partner in existing supply chains and create new ones
- identify and benefit from areas of mutually supportive expertise

With greater understanding and better networks with India, UK manufacturing companies can also benefit from more rapid identification, evaluation and adoption of emerging technologies and systems, for example those used by UK and Indian SMEs to improve performance of plant and equipment.

Increased visibility and presence of UK companies in India through supported collaborative activity will also increase the possible research and development investments by Indian companies into UK companies, universities and research organisations.

A wider collaborative programme would also help to spread good practices and adoption of standards to increase competitiveness in Indian markets and help to increase local and global market opportunities.

## Increasing global competitiveness

Each of the opportunities outlined above could improve the strategic, operational and financial competitiveness and performance of UK companies and increase productivity and global competitiveness for both the UK and India. As the UK moves towards leaving the European Union, the opportunity to revisit, refresh and enhance its relationship with India through a collaborative approach, seeking to deliver benefits to both partners, is timely and with strong potential benefits to both countries' manufacturing sectors.

Areas developed for collaboration must be ones that allow potential economic growth and productivity to be shared equitably between the UK and India.

## Strengths and weaknesses

The panel considers the strengths, weaknesses, opportunities and threats to consider in a wider programme of collaboration.

Strengths	Weaknesses
<p>The UK has a well-developed high value manufacturing sector that performs well in R&amp;D</p> <p>Existing collaborative innovation between UK &amp; India, for example Newton-Bhabha</p> <p>Strong historic ties with India (common language, legal system and approach to intellectual property)</p> <p>Mutually supportive national goals for high value manufacturing</p> <p>Significant areas of overlap for manufacturing sectors, for example defence, aerospace and automotive</p>	<p>Cost of collaboration</p> <p>Cultural differences (both business and societal)</p> <p>Reduced demand in manufacturing sectors due to previous economic slumps</p> <p>Visibility and understanding of existing innovation funding support</p>
Opportunities	Threats
<p>Common areas of interest:</p> <ul style="list-style-type: none"> <li>● increasing productivity and lowering cost for manufacturers</li> <li>● building a robust supplier base</li> <li>● education and skills</li> </ul> <p>Current UK government focus on developing international collaboration</p> <p>UK intention to leave EU and effect on currency have changed conditions for export and international trade</p>	<p>Productivity gains from innovation (for example in automation) may lead to short-term job losses that will need to be balanced against public and private sector goals</p> <p>Skills availability and ability to re-skill</p> <p>Cost of scale-up to SMEs and reluctance to invest</p> <p>Public procurement and regulation needs to enable manufacturing innovation</p> <p>Wider national concerns, for example:</p> <ul style="list-style-type: none"> <li>● (UK) need to ensure equitable benefit from collaboration for both UK and India</li> <li>● (India) concerns related to ease and efficiency of movement of workforce between India and UK</li> </ul> <p>International competition from other countries with strong capability in high value manufacturing, such as Germany and Japan</p>

## Possible programmes

A range of schemes to support innovation could be considered within a wider programme delivered jointly by Innovate UK, BEIS, DIT, and FCO SIN. Further work is required to develop a full business case for investment and ensure the activity would deliver benefits to both the UK and India.

A steering group would need to be formed to develop and coordinate the programme, with balanced representation from the public and private sectors.

Elements of innovation support could include:

- a joint support network for UK companies in India, based on the current Innovate UK Knowledge Transfer Network, connecting UK companies and institutions with Indian counterparts and supporting access to funding
- collaborative research and development funding competitions addressing challenges faced by Indian manufacturing. These could be co-funded, or have only UK company funding available to support UK companies
- demonstration projects to support translation of technology from the UK to the Indian market
- events based on the current Innovate UK investor and technology showcase programme. These could be linked to current DIT inward investment activity
- a scheme to match Innovate UK-funded projects and relevant companies to the Indian market, delivered via DIT
- advanced manufacturing mission. Successful web and future cities missions to India have already been run. A longer-term programme that provided continuous support could also be considered
- an India-specific lead customer programme along the lines of SBRI (Small Business Research Initiative) that would support UK companies working with Indian partners to solve challenges faced by large Indian organisations or public bodies
- UK-Indian centres, based on the Catapult model to act as a focal point for collaboration and promote the UK Catapult centres in India (this could go further than the High Value Manufacturing Catapult, and for example include Future Cities, Satellite Applications). This activity would need to be considered against the Catapults' core mission to support and accelerate UK-based businesses, though it would also allow for the current range of Catapult work with India to be consolidated and its specific impact measured
- UK to work with India to develop its own Catapult network. Centres could be created to accelerate innovation specific to India's requirements and challenges and to provide stronger links to the UK
- supporting specific UK industry or academic-led innovation centres in India. For example, there are 2 initiatives exploring creation of a centre in India, one led by the Institute of Manufacturing in Cambridge with NIAS and another led by The Welding Institute working in partnership with others, including Bharat Forge







# Next steps

**The following suggestions are ways in which the ideas in this report could be developed.**

- 1** Establish a UK-based steering group across Innovate UK, RCUK, BEIS, DIT, FCO SIN to consider and guide future thinking.
- 2** Organise a UK-based workshop to test the concepts outlined in this report with UK businesses and research organisations.
- 3** Investigate the business case for a wider advanced manufacturing collaborative programme against some or all the possible programme elements.
- 4** Hold a bilateral event to establish a strategic dialogue between both countries involving commercial, academic and policy makers in India and the UK.
- 5** Define possible areas for joint funding competitions in advance manufacturing for Newton-Bhabha (and beyond) using the range of themes identified in this report as a starting point.
- 6** Plan and deliver in conjunction with the Indian Department of Science and Technology a sandpit-style event to map challenges and opportunities in sustainable manufacturing.
- 7** Investigate the feasibility of and business case for 'Catapult-like' centres in India.

## Appendix 1

### Themes from individual Indian companies

During the course of researching this report interviews were conducted with various Indian companies to identify areas that were felt to offer the opportunity for collaborative innovation, the following table summarises identified themes.

Company	Themes
<b>Godrej</b>	Refrigeration and Cold Chain (Thermoelectric & solid state approaches) Products for rural India Smart building management Servitisation approaches for manufactured goods
<b>Aditya Birla</b>	Light-weighting Digital Manufacturing (Industry 4.0) Flexible Manufacturing Retrofit automation (due to challenge of increasing labour costs) Waste treatment & valorisation Pollution control and 'zero emission plant' technology
<b>Tata Group</b>	Energy generation, provision and management (focus on fuel cell technologies) Food Security (focus on drone based agriculture and pest control) Digital technology (focus on factory safe wearable's) Factory & Fleet Analytics (current focus on boilers / heat sources) Industry 4.0 Refrigeration and Cold-chain
<b>Tata Consultancy Services</b>	Digital Supply Chain Management Energy efficiency / Smart energy systems
<b>Bharat Forge</b>	Composites – for high volume manufacturing Affordable composites Laser & Electron Beam welding Remanufacture (esp. In situ) Powder manufacture / 3D NVH & tribology (design for NVH, grain size etc.) EV & hybrids Energy storage & battery management Sensors Emission treatment
<b>CESG Power</b>	Power generation Valorisation of by-products (e.g. fly ash from incineration based generation) Smart grid management Energy efficiency Retrofit solutions
<b>IFB</b>	Digital supply chain management Rapid prototyping Advanced joining technologies Energy efficiency Lightweighting Novel materials Pollution control 'zero emission plant'
<b>Unilever (HUL Ltd.)</b>	Water & water treatment Microbiology & Healthcare Sustainable Packaging
<b>CMTI, Bangalore</b>	Nano manufacturing Metrology Sensors & vision technology Additive Manufacturing (3D printing) Smart manufacturing



## Appendix 2

A summary of the challenges identified for Indian manufacturing across various themes is given in the following table:

Theme	Notes
<b>Product Innovation Culture</b>	India needs to develop a product innovation culture; linking unmet market needs with design solutions. Prototyping facilities; maker spaces and mentoring can facilitate small-scale manufacturing start-ups and new product development.
<b>High end talent</b>	Specific gaps in skills and knowledge should be identified and addressed, for example – laser welding & smart factories. Drawing on external partners (e.g. overseas collaboration) can assist.
<b>Manufacturing scale-up</b>	Moving from prototype to pilot batch and then on to full production. Particularly for small-scale, distributed manufacturing start-ups and innovative technology (e.g. affordable medical devices)
<b>Product lifecycle engineering</b>	Including: design for manufacture, serviceability and better end-of-life performance. Cloud-based digital platform's and tools for product design, process optimisation and supply chain management.
<b>Advanced Materials</b>	Especially for aerospace; medical devices and applications; additive manufacturing and 2D materials. Support for development of local supply chains from raw material production to effective end-of-life outcomes.
<b>Feeder Technologies</b>	Development, adoption and localisation of new manufacturing technologies to support value creation and quality enhancement, e.g. nanofabrication; metrology and additive manufacturing.  Opportunities for new product classes, for example flexible electronics.
<b>Smart &amp; distributed manufacturing</b>	Digital approaches to linking operations both within and between manufacturing facilities and separate organisations; supply chain improvements driven by sensing, big data and analytics.
<b>Standards for production &amp; testing</b>	For functionality, quality, usability and safety. Alongside testing equipment, protocols and standards to enable supply chain development.
<b>Smart &amp; Sustainable Manufacturing</b>	<ul style="list-style-type: none"> <li>● Sustainable shipping and alternative marine propulsion</li> <li>● 6R approaches (reduce, reuse, recover, recycle, redesign and remanufacture)</li> <li>● Environmental design and manufacture</li> <li>● Whole life product passport and reverse logistics</li> </ul>

## Appendix 3

A summary of the outputs of the UK's April 2016 workshops

Theme	Notes
<b>Education and Skills</b>	Address skills and engagement at all levels to improve skills for digital, robotics, automation, AI Professionals – training courses, secondments, collaboration between industries
<b>Industrial Internet</b>	Secure backbone for SMEs Open source platform for supply chains Demonstrators
<b>Digital Manufacturing (Industry 4.0)</b>	In silico/simulation first – getting it right first time Adoption of automation systems – increasing capacity, increasing quality Robotics, automation and artificial intelligence 'Big' data Training
<b>New Bus Models</b>	Moving from traditional manufacturing firms to information based firms (i.e. an Uber model for manufacturing) Intelligent manufacturing systems Reduce product development cycle Distributed manufacturing Flexible, configurable factories (e.g. smart/adaptive tooling, reconfigurable production lines).
<b>Circular Economy</b>	Optimise process to reduce waste Understanding hierarchy of waste across manufacturing sectors to get more value from necessary waste Recycling 'molecular stewardship' Zero waste manufacturing (net shape) Net +ve manufacturing Material substitution
<b>International</b>	Export support Supply chain development Identification of opportunities for onshoring/reshoring
<b>Advisory Services</b>	Funding for manufacturing advisory service programmes to support SMEs
<b>Decommissioning</b>	Robotic/automated approached
<b>Advance Maintenance, Metrology &amp; Sensors</b>	Advance/predictive maintenance
<b>Additive Manufacturing</b>	Design for additive manufacturing Mass customisation
<b>Design</b>	Systems design Product design
<b>Energy</b>	Energy efficiency Industrial generation Surplus energy use
<b>Bio-industries</b>	Industrial biotechnology Biomaterials Synthetic biology
<b>Lightweighting</b>	New multi-content material e.g. fibre and matrix Joining different materials Design for manufacturing

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