The Current and Future Role of Technology and Innovation Centres in the UK

A Report by Dr. Hermann Hauser

For Lord Mandelson

Secretary of State
Department for Business Innovation & Skills

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Table of Contents

Foreword from
Dr. Hermann Hauser

For most of my working life I have been involved in creating and supporting innovative ideas across many different sectors, and I have worked with over a hundred companies. All of them have had university-educated teams at their core, with technologies coming from universities, industrial research laboratories, consultancies and other companies. Four became billion dollar companies, some were moderate successes, and others failed.

Two factors dominate the chances of success: the quality of the team, and the readiness of the technology.

In this report, commissioned by Lord Mandelson in 'Going for Growth: Our Future Prosperity' published in January this year, I concentrate on the readiness of the technology after its initial discovery, and in particular, the role played by a 'translational infrastructure' in the form of Technology and Innovation Centres.

The recent Royal Society report, "The Scientific Century", places science and innovation at the heart of the UK's long-term strategy for economic growth. However, it has become clear that the leisurely translation of scientific discoveries into new industries has been replaced by a race between nations to take advantage of these discoveries and translate them into economic success stories before others do so.

The UK Government's 'New Industry New Jobs' policy statement marked a welcome shift in thinking on the role of strategic and 'active' government in developing and capitalising on competitive advantage.

The UK has a science capability second only to the US: an undoubted source of competitive advantage. However, it falls short on translating scientific leads into leading positions in new industries.

This is in part down to a critical gap between research findings and their subsequent development into commercial propositions that can attract venture capital investment or be licensed. This gap can only be closed by making new technologies investment ready.

Therefore, if the UK is serious about creating a 'knowledge-economy', we must continue to invest in, and support, research excellence; ensure we support areas of UK industry which have the ability and absorptive capacity to capture a significant share of high value activity; and close the gap between universities and industry through a 'translational infrastructure' to provide a business-focused capacity and capability that bridges research and technology commercialisation.

Other countries benefit greatly from a translational infrastructure that bridges this gap – for example, the Fraunhofer Gesellschaft in Germany, ITRI in Taiwan, ETRI in South Korea, and TNO in the Netherlands.

In this report I propose that the UK develops an equivalent capability and that attention should be focused on providing sustained and substantive support for an elite group of Technology and Innovation Centres, branded 'Clerk Maxwell Centres', that aim to exploit the most promising new technologies, where there is genuine UK potential to gain competitive advantage. This will help deliver the new industries, with transformational economic impact, of the future.

I urge the Government to implement these recommendations speedily as they will have a substantial effect on the long-term competitiveness and therefore prosperity of the UK.

Dr. Hermann Hauser
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Executive Summary

The 21st Century will be a time of rapid innovation and technological change that will be spurred on by the grand challenges that we face, including climate change and the demands of an ageing society. Significant opportunities for technology-based products and services will also emerge from increasingly open, competitive and affluent global markets.

This period of rapid change will create both opportunities and challenges to the UK, and the deepest economic crisis since the Great Depression of the 1930s brings the need for an innovation system that enables the UK to emerge strongly from the downturn into sharp focus.

The UK has a leading position in research, but it has long been acknowledged that it has not sufficiently capitalised on these strengths to capture economic benefit. This is in part down to a critical gap between research findings and outputs, and their development into commercial propositions.

Technology and Innovation Centres can enable industry to exploit new and emerging technologies, by closing this gap through the provision of a business-focused capability that bridges research and technology commercialisation.

Other countries have powerful capabilities such as these which operate mission driven environments that receive ongoing support from the public sector and leverage significant funds from industry. These have had a transformative effect on their industrial base including ITRI creating the display industry in Taiwan, and ETRI establishing South Korea as a major semiconductor producer.

While the UK has invested in equivalent structures, the report shows that the current UK approach is by comparison sub critical; follows no national strategy; and pays insufficient attention to business requirements and the location of relevant expertise.

The report therefore calls for a new approach to investments in Technology and Innovation Centres that can deliver a step change in the UK's ability to commercialise its research. It calls for the UK to make choices and focus its attention on developing such a capability for platform technologies only where: there are large global markets worth billions of pounds per annum; the UK has technical leadership; there is a defensible technology position; and, there is capacity to anchor a significant part of the value chain, from research to manufacturing, in the UK.

There are already a number of candidate technology areas including, stem cells and regenerative medicine; future internet technologies; plastic electronics; software & technologies addressing renewable energy and climate change; satellite communications; fuel cells; advanced manufacturing; and composite materials, amongst many others.

The 14 recommendations in this report set out in some detail the mission, strategy, funding requirements and governance for these Technology and Innovation Centres. The recommendations also include a call for these centres to carry a unique brand, such as 'Clerk Maxwell Centres', to highlight areas of national priority to both UK businesses and to promote the UK's innovation offer to the world.

Chapter one:
Scope and Purpose of the Review

Introduction

The UK has a strong track record in science and innovation. It possesses four of the world's top six universities[1], and a research base that is now second only to the US in the G8 group of countries for excellence, producing 12% of all cited papers and 14% of the most highly cited papers[2]. The UK is also recognised as one of Europe's 'Innovation Leaders'[3].

For over a decade, Government policy has consistently supported the development of the UK's scientific and technological capabilities. This has been underpinned by record levels of investment in science of over £40 billion. Policy documents, including the 10 Year Funding Framework for Science and Innovation, Lord Sainsbury's report on Science and Innovation (*The Race to the Top*) and the Innovation Nation White Paper, have set out Government's future commitment to continue to invest to build on these strengths and address weaknesses, including the UK's ability to better translate the outputs of record investment in science and research to capture economic benefit for the UK.

This report is focused on the specific challenge of capturing economic benefit from the UK's excellence in generating knowledge. While good progress has been made in driving a major culture change in the UK's universities, who are engaging with businesses at unprecedented levels, it is quite apparent from international comparisons that it is urgent to do considerably more to capitalise on the outputs of this powerful research base.

Scope of the Review

The purpose of this review is not to analyse innovation policy overall. It is focused on assessing, and making recommendations on the UK's approach to a specific component of its innovation system, the role of business-focused Technology and Innovation Centres (TICs). These can play a key role in enabling better knowledge transfer, by acting as a bridge between the research base and industry (see Terms of Reference in Annex A).

An international comparison of TICs in a number of countries including Germany, France, the Netherlands, Taiwan, South Korea, and China amongst others, documents the benefits these countries derive from a national technology strategy that strongly integrates the role of TICs into the innovation system.

In the UK, a range of public sector bodies have invested in centres to address objectives aligned with their core remit. These include:

- **Research Councils**
  primarily aimed at supporting excellent academic research, often with a clear requirement to address business or societal needs or opportunities;
- **The Technology Strategy Board**
  supporting technology development and innovation for the benefit of business, which includes national programmes of activity in which a range of centres participate;

1 Times Higher Education Supplement/QS Ltd international league table of universities
2 International Comparative Performance of the UK research base, September 2009 (http://www.dius.gov.uk/assets/bis-core/corporate/migratedd/publications/i/icpruk09v1_4.pdf)
3 2007 European Innovation Scoreboard

- **Regional Development Agencies** focused on driving regional economic growth and investing in centres as strategic drivers of this; and
- **National Government/Devolved Administrations** a range of investments or co-investments to develop a strategic capability or address market failure.

The UK also has a number of independent, Research and Technology Organisations (RTOs) providing businesses with support to help develop new products and processes.

For the purposes of this review, TICs are defined as organisations focused on the exploitation of new technologies, through an infrastructure which bridges the spectrum of activities between research and technology commercialisation. These can be in both established technology areas and in new, emerging technologies.

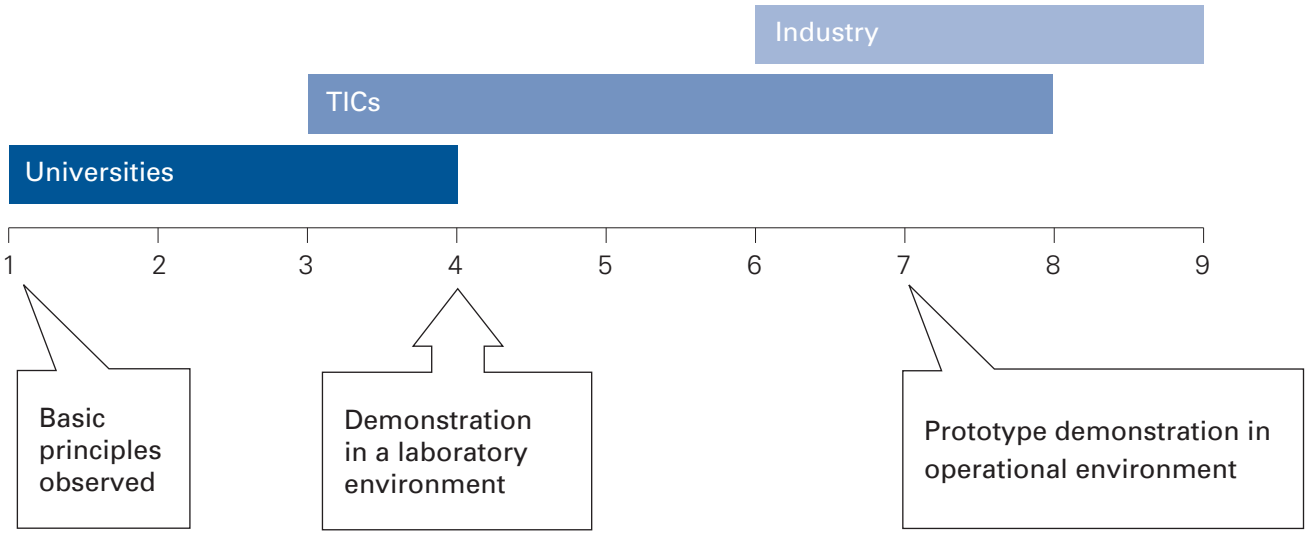
TICs are mission-driven organisations that develop their own in-house knowledge and capability by working closely with leading Universities and other TICs including through public sector funded R&D and innovation programmes. This, combined with an open access technology infrastructure, and the provision of contract research, enables companies to share the costs of R&D, access skills and equipment which might not otherwise be within their reach, and so reduce risk, shorten time to market, and exploit synergies of know-how across the value chain. Typical activities and outputs of TICs therefore include the development and scaling up of manufacturing processes, and the production of technology and application demonstrators (see Figure 1).

Most of these organisations receive at least some public sector funding to cover either capital costs associated with start up, expansion, or R&D projects they are undertaking, with further funding secured on a competitive basis, mainly from UK and EU programmes, alongside industrial contract research.

Therefore, the definition of TICs includes independent RTOs that fulfil a similar function, but are distinct from, though complementary to, that of Universities and Research Council funded centres. However, close working between these parties and industry is critical to overall success.

The following diagram shows the position of the different players in the technology development cycle according to their Technology Readiness Level (TRL), a widely used scale used by the US Department of Defence, the Ministry of Defence and NASA.

Figure 1
Technology Readiness Levels



The remit of this review does not therefore include the important role played by University Technology Transfer Offices, Science Parks, centres and labs that support public policy such as environmental protection and occupational safety, or clusters, each of which have a key role in the innovation ecosystem.

Context and Economic Rationale

New technology sectors can quickly change the economic landscape of a country and the world. This occurred in the 18th Century, through the Industrial Revolution.

In the late 20th Century, the rapid uptake of consumer electronics in the 1970s was followed by the development of personal computers and ultimately the internet. Although these latter developments took place in the last 30 years, they have already changed the lives and working habits of a generation. Countries willing and capable of taking advantage of these new technologies prosper, where others fall behind.

It used to take many years, often decades, for academic discoveries to be commercialised. This has changed into a race between nations to bring new technologies to market more quickly, to gain first mover advantage and establish a dominant market position in the following years. This was achieved by the US through the rapid commercialisation of technologies such as semiconductors, computers, and the internet.

There is no reason however to believe that smaller countries cannot compete as Finland has shown with Nokia, a company that enjoys a dominant position in mobile telephone handsets. This was built on an early lead in mobile telephony by the Scandinavian countries.

The UK at present enjoys a leading position in research in a number of technologies, which have the potential to become large new sectors in the future, and this report is written in the context of trying to ensure this research lead is translated into an economic success for UK plc.

Investment in innovation is essential for a successful economy. Research suggests that an increase of 1% in business R&D investment increases multi-factor productivity by 0.13%, and a 1% increase in public sector R&D achieves a multi-factor productivity increase of 0.17%[4]. Other evidence suggests that innovative companies increase their turnover and increase employment more rapidly than non-innovators[5].

Technical and commercial uncertainty is one of the pervasive features of innovation processes, particularly in the pre-competitive development of new ideas with the seeds of commercial potential[6]. This is a phase where uncertainty of outcomes is associated with the highest financial risks in the funding of new projects or new ventures. This stage in the commercialisation process attracts very little investment from the venture capital market or business angels, and is usually undertaken by only the very largest industrial companies[7].

Matching technologies to markets and demonstrating their ability to create value to customers and investors is a key process for successfully commercialising emerging technologies[8]. It is through this process that new industries are developed through the formation of clusters of companies, and value chains that generate revenue around early products. The development of these platform technologies, or technologies which underpin a wide range of applications, often spanning many business sectors, enables the creation of new markets, or generates significant changes

4 OECD, 2004, a study of 16 countries, including the UK, between 1980 and 1998.
5 NESTA Innovation Index, 2009. This found that companies introducing a new product (2002 to 2004) saw average employment growth of 4.4% during the subsequent 3 years (2% for non-innovators). Innovators saw 10% growth in turnover; compared to 5.8% for non-innovators.
6 Gregory Tassey – Rationales and mechanisms for revitalizing US manufacturing R&D strategies, J Technol. Transf., Jan 2010.
7 Mina, A., Connell, D. and A. Hughes, 2009, 'Models of Technology Development in Intermediate Research Organisations', CBR Working Paper n. 396, University of Cambridge.
8 Clayton Christenson – The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail, Harvard Business School Press

in existing markets. This feature creates the opportunity for large spillover benefits, but also poses the challenge of how to ensure that those opportunities can be capitalised within the national innovation system.

Businesses only rarely innovate in isolation, and often draw in information and knowledge from external parties. This happens via skilled people; collaboration with other firms (most often, customers and suppliers); and cooperation with universities and non-university institutes that engage in research and problem-solving.

The conduct of innovation is not only becoming more distributed, but it is also displaying signs of increased complementarities: inputs to the innovation process complement one another so that the total is more than the sum of its parts. This means that any weakness in a part of the innovation system disproportionately affects the performance of the whole system. In the case of platform technologies, with their considerable potential spillovers and increasing global competition, a successful innovation strategy has to rely on an approach that pursues excellence across all key innovation capabilities in support of the development of competitive advantage.

Amongst the wider set of innovation policy instruments, TICs are particularly valuable where there is a strong case for developing a research and pre-commercialisation capability as the means to addressing the ultimate innovation challenges. The rationale for public support for TICs stems from the barriers to strategic and co-ordinated capability development, which may apply to infrastructure, equipment and skills which would not otherwise be in place.

They exist in large part to help firms innovate, and to solve innovation problems that are beyond the capabilities of individual firms. Infrastructures such as these are also difficult for individual firms to procure for themselves or provide for others on a purely commercial basis, given the scale of coordination barriers and transaction costs. They are large, long-lasting, for the most part indivisible, and are used collectively by most or all economic actors.

By bringing activity together into a single location, TICs can provide a focal point to the research and innovation activities of companies, particularly new ones, and provide access to the facilities and expertise needed to pursue their innovation objectives successfully in a competitive global marketplace. Shared access to research equipment and instruments and the exchange of tacit knowledge are significantly facilitated by co-location. This includes the learning from collaborators' research failures, which helps avoid wasting resources pursuing fruitless lines of research. TICs provide a direct focus for effective collaborations which are unlikely to take place without the co-location and network opportunities they enable. Although this focus on co-location could be said to imply there is a risk that non co-located business and researchers would be disadvantaged by this, the use of new communications technologies enables this problem to be managed. Therefore, the benefits of investing in TICs can outweigh potential risk and costs.

TICs therefore have the potential to help the UK overcome the problem of translating its leading research into economic benefit, which has traditionally been an area where UK performance has been relatively weak. Body scanners and Application Specific Circuits are all well documented examples of the past, and it is becoming ever more important that the UK address this weakness.

Chapter two: International Comparisons

Summary

- The specific role of Technology and Innovation Centres (TICs) varies according to the innovation system and economic and social landscape of the countries they operate in.
- However a shared rationale exists for developing TICs that bridge the gap between academic discovery and commercial exploitation.
- It is common for TICs to be focused on sectors or technologies which capitalise on local and national strengths rather than have a wider spread of institutes in many technology or sectoral fields.
- Most benefit from long-term, sustained and predictable flows of public funding, although the level and type of funding varies significantly.
- The workforce is recruited from the academic and private sector and possesses research, technology development and commercialisation skills.
- The TICs are expected to supplement core funding by winning additional income from public and private sector contract research, and through the commercialisation of IP.
- Strong governance structures are in place in many to provide strategic direction and ensure the quality of services provided to business.
- Almost all operate with a high degree of autonomy to manage the achievement of their objectives.
- A strong brand has been found to reinforce a TIC or network of TICs by making them a more attractive partner to the private sector and for international collaborations; and
- International collaborations are widely undertaken with many within the EU, leveraging significant funding from the Framework Programme.

Introduction

The Terms of Reference for this review include evaluating the roles and performance of Technology and Innovation Centres (TICs) overseas, to identify international best practice. The review has explored the role of TICs in 12 countries: Germany; South Korea; Sweden; France; China; Denmark; USA; Japan; Singapore; Israel; Belgium, and the Netherlands. It has drawn on published research papers and other publications, as well as information gathered by the UK Government's Science and Innovation Network.

Rationale for TICs and their role within the innovation system

An OECD economic survey[9] of Spain in 2007 stated that, "promoting technology centres, which rely on demand by end-users, is a useful way of encouraging a culture of innovation while simultaneously limiting the risks of wastage". Most countries studied here identified the need for TICs (also commonly referred to as the 'intermediate sector') as a critical element to deliver governmental, or wider public sector, policies and strategies to promote innovation. The underlying rationales included:

- France identifying that its internationally acclaimed research base was not producing breakthrough innovations in new technologies and that there was little collaboration between sectors and weak links between the research system and industry. The network of Carnot Institutes was set up from 2006 to address this gap.
- Operating 3 to 10 years ahead of industrial needs and to foster the development of the local industrial base through the creation of spin-out companies, promoting R&D collaboration and developing technology skills with business for the Inter-University Micro Electronics Centre (IMEC) in Belgium; and
- Facilitating the development of the semiconductor industry in Taiwan, as universities were not considered a suitable environment for commercialising technologies, by establishing the Industrial Technology Research Institute (ITRI)[10].

The role and rationale of TICs is therefore context dependent, which also includes the presence and nature of other academic or business centres of excellence; the balance of business sectors; and the importance attached by the public and private sector to innovation within a particular nation. This is an important point to bear in mind when considering the transferability of a 'model' from one country to another.

As discussed later, the support for, and exploitation of, a national or regional strength in one industry or technological field is often a major part of the rationale for TICs. They frequently focus on a sector or technology rather than have a wider spread of investments in many technology or sectoral fields which, whilst being highly successful for the Fraunhofer Institutes in Germany, is less common.

The breadth of the roles of the TICs in the countries investigated can be broadly summarised to include:

- undertaking basic research;
- carrying out applied research in the innovation chain between university-generated initial discovery and industrial development to realise its commercial potential;
- enabling SMEs to innovate though provision of knowledge, equipment and applied research;
- providing technical and commercialisation services to large and small companies; and
- developing a highly skilled workforce.

The Fraunhofer Institutes and the Electronics and Communications Research Institute (ETRI) in South Korea, for example, fulfil all of the above roles, while the Chinese initiative (Torch Centres) also incorporate direct investment and business incubation in an integrated way. The GTS network (translated as Authorised Technological Service Institutes) in Denmark is, however, focused mainly on SME services and short-term contract research.

9 "OECD policy brief, Economic Survey of Spain 2007, OECD, Paris, January 2007"

10 The growth of ITRI was inextricably linked with the development of the Taiwanese semiconductors industry in the mid 1970s and two of its 1980s spin-offs (UMC and TSMC) grew into market leaders of the global semiconductor business.

There are risks however in publicly funded TICs straying too far into fundamental research. It has been noted that ETRI is now competing with universities as well as collaborating with them, and being viewed by businesses as operating too far from the market[7].

Where support for SMEs is a key objective, additional services are also provided and can include:

- marketing, commercialisation and IP advice;
- venture capital advice incubation of small companies and seed funding; and
- help in securing public grant support funding, to take advantage of tax credit schemes and to win public sector procurement contracts for products or services.

In addition to TICs, the US also has a strong intermediate sector of private companies, which have been established specifically to develop technologies or solve technology problems for the public or private sector. A number of these benefit from the Small Business Innovation Research (SBIR) programme, or related programmes such as the Small Business Technology Transfer (STTR), Advanced Research Project Agency-Energy or Defence Advance Research Projects Agency (DARPA) schemes. These programmes offer the opportunity for SMEs to compete to win fully-funded contracts to develop technology-based solutions that meet the needs of the public sector.

Organisations such as DARPA also run outcome focused programmes, which in this particular case focus on developing a US supply chain that can provide technological options for the Department of Defence. It has been influential in taking forward an integrated approach to their support for the development of new technologies including the development of computer networking as well as NLS, which was both the first hypertext system, and an important precursor to the contemporary ubiquitous graphical user interface.

Funding

Both the level and type of funding for TICs varies significantly between countries. However, the sources of funding can be broadly categorised as:

- **Core funding** from national and regional government. While this funding is not always linked to specific activities or outcomes, a performance management framework is often in place where TICs receive this investment;
- **Research grants and contracts** from public bodies, in most instances won on a competitive basis; and
- **Research contracts from the private sector**, usually competitively tendered.

In addition, TICs also benefit from other sources of income. These include funds from licensing or the commercialisation of intellectual property; membership subscriptions; or through subsidised access to facilities. The extent to which individual TICs, or a network of national TICs, benefit from each of the aforementioned sources of funding varies (see Table 1).

The National Institute for Advanced Industrial Science and Technology (AIST) in Japan, for example, receives nearly all its budget from public research funding, the majority bid for competitively. GTS in Denmark operates at the other end of the scale, with core funding accounting for only 10% of its total budget.

A more balanced model appears to be that of the Fraunhofer Institutes, which receive around one third of their budget as core funding, and aim to generate a further third through public research projects that are competitively bid for (at national, Laender (regional) or EU level), and a final third from research contracts with the private sector.

The Carnot Institutes in France also obtain more than one third of their funding from research projects with industry.

Table 1
Funding for Selected Technology and Innovation Centres % Income, 2008

	Gov/State Core	Other Public Funding	Private Sector Funding	Licensing Funding etc
AIST[11] (Japan)	70	21		
ETRI (South Korea)	26[7]		74	0.2
TNO (Netherlands Organisation for Applied Scientific Research)	33	15	37	15
Carnot (France)	59		41	
Fraunhofer Institutes (Germany)	35	23	34	7
GTS (Denmark)[12]	10	10	78	

Core funding from the public sector appears to be most in need at start-up for infrastructure and capacity building, but studies have shown a need for continued core funding for three functions: strategic high-risk research of medium to long-term duration; competence development; and the acquisition and maintenance of large-scale facilitates and specialist equipment[13].

Low levels of core funding in Sweden (only 7%) were found in a 2006 study to lead to a focus on short-term projects and services to businesses[14]. The study recommended a minimum of 30% core funding, and the Swedish Government has since increased its contribution.

A review initiated by the Science and Technology Policy Council of Finland[15] reached similar conclusions and has led to an increase from 30% to 40% of core funding for the Technical Research Centre of Finland (VTT). Furthermore a study of the Danish GTS[16] in 2009 recommended that, whilst the aim and focus of the TICs were on supporting SMEs rather than long-term research, core government funding should nevertheless increase to 20% to enable it to build better knowledge platforms.

However, TICs with lower core funding do benefit from other forms of public funding[15], often publicly funded research projects won competitively, or through multilateral public research budgets such as the EU Framework Programme. Some TICs also benefit from close relationships with universities or other research institutes, for example through free or subsidised access to facilities.

11 AIST also receives an additional public funding stream of 9% of its income to support facilities
12 Private sector funding includes substantial international sales, and the core funding can be used with other public funding for either R&D or to support infrastructure etc
13 EARTO 2007 "Research and Technology Organisations in the Evolving European Research Area: A status reporting with policy recommendations" http://www.earto.eu/fileadmin/content/03_Publications/RTOs_and_the_Evolving_European_Research_Area_WhitePaperFinal.pdf
14 Arnold, Brown, Eriksson, Jansson, Muscio, Nahlinger, Samas, Technopolis December 2006, "The role of Industrial Research Institutes in the National Innovation System: A report to VINNOVA"
15 EARTO 2007 "Research and Technology Organisations in the Evolving European Research Area: A status reporting with policy recommendations"
16 Sorlin and Arnold, February 2009, "A step beyond: International Evaluation of the GTS Institute System in Denmark" (Forskinngs-og Innovationsstyrelsen)

TICs in several countries are also now being encouraged to gain more private sector funding, though importantly, not necessarily as a replacement for public subsidy. It is common to find extra government funding available as a bonus where a TIC gained a defined amount of contract work. For example, the Carnot Institutes can receive up to €60m in supplementary funding from the government in proportion to the volume of funding generated through their contract work with the private sector.

Governance, Promotion of the Network and Operations

(i) Governance

The countries studied here have different models for the governance and management of their TICs, from formally governed groups, to ad-hoc TICs with little or no networking between the individual TICs.

Formal governance and grouping is common, for example in Germany, Japan, and South Korea. The Fraunhofer Institutes in Germany have a complex structure including Members, a General Assembly and a Senate. These formal structures have the benefit of being able to set strategic direction, research activities and carry out performance evaluation. However, within this federal structure, individual Fraunhofer Institutes do have a high degree of autonomy to set their own research priorities and pursue commercial opportunities, and to compete with each other to win funding from business or the public sector.

The French Carnot system has a Members' Association, which acts in a similar way to a trade association, promoting the brand and providing some shared membership services, although there is no common governance structure. Within the GTS system in Denmark, non-profit companies within the private sector with relevant technological expertise are authorised by the Danish Ministry of Science, Technology and Innovation to use the appellation. The authorisation is given for a three-year period and currently only nine organisations in Denmark are authorised to do so. After three years, these organisations need to be reaccredited. These looser networks still have the benefit of shared experience, can promote easier collaborations and have the ability to ensure the quality of services provided.

There is evidence, from a Technopolis study of five comparison institute systems (Denmark, Germany, Sweden, Finland, and the Netherlands) for the Danish Government[17] that the German model of grouping has led to an ability to rapidly and flexibly set up expert networks, which gives a competitive advantage. The same study also found that the GTS institutes were at a disadvantage compared to the other four networks of centres, as the others had more unified governance systems, which allowed control to be exerted where needed. By way of contrast, some studies criticise the highly bureaucratic structure of the Fraunhofer Gesselshaft as creating a rigidity which means it retains a focus on sectors traditionally strong in the German economy at the possible detriment of emerging sectors. This may make the argument in favour of strong, but 'light-touch', governance and networking structures[7].

The Technopolis study[17], concluded that government ownership was not necessary for a strong TIC, but sustained government commitment was needed, and that this required strong promotion of the role of TICs in the innovation system, alongside universities and other research institutes.

As noted before, it is common for the government, or the organisation in charge of the TICs, to focus their activities on sectors or technologies which capitalise on local and national strengths, rather than have a wider spread of institutes in many technology or sectoral fields. For example, ITRI in Taiwan was set up to help build one specific industry, and TNO in the Netherlands devises its

17 Astrom and Arnold, Faugert &Co Utvardering AB, Technopolis, December 2008, "International Comparison of Five Institute Systems" (Forsknings-og Innovationsstyrelsen)

research programmes to support social themes developed in close cooperation with the government. By contrast, the Senate of the Fraunhofer Gesellschaft in Germany is responsible for deciding the society's basic research policy and is made up of eminent figures from the world of science, business, industry and public life, as well as government. The context and level of available funding is important, and Germany has been very successful in its broad approach. However, it is also clear that where a focus has been placed on a single area of expertise, such as with ITRI, this has led to very high levels of expertise in their areas of focus.

(ii) Promotion of the network

In many countries where structured networks of TICs exist, and in some looser structures such as Carnot and GTS, a common brand is used to identify organisations that are part of a wider network, and provide assurance to business and other potential partners.

Although it is difficult to assess the value of these common brands, it is widely believed in Germany that the renewal and greater use of the Fraunhofer brand in recent years has made a difference and has enabled the network to promote itself and compete effectively both nationally and internationally.

(iii) Operations

To fulfil their diverse roles, TICs balance the composition of their workforce between academic scientists, and those with industrial and commercialisation experience, as both sets of skills are essential to their role. This also has the benefit of improving their respective skills sets if they return to academia/industry. One third of the staff at IMEC in Belgium are employed by its industrial and academic partners, which generates active collaborations and facilitates the efficient transfer of knowledge from fundamental research at universities to industrial applications. AIST in Japan also actively recruits secondees from SMEs to develop their research and innovation skills and sends its researchers on secondment to SMEs to speed up technology transfer.

The international role of centres

International collaborations are encouraged and incentivised in many countries, as there is consensus that international relationships are integral to good research[18].

Chinese TICs have specific incentives to encourage international collaboration, while there are requirements to build international collaborations in the case of Carnot Institutes. ETRI in South Korea carries out collaborative research with organisations in 25 countries and the Fraunhofer Institute has subsidiaries in the US and Austria, and operates research centres in Poland, Portugal and Greece as well as representative offices around the world. However, most TICs do not generate a significant level of revenue from their international activities. GTS (Denmark) is a notable exception, with 43% of its revenues coming from abroad in 2007.

Many TICs within the EU also actively seek collaborations in order to access funding from the EU Framework Programme. This includes collaborations between TICs with, for example, TNO in the Netherlands cooperating on one particular FP7 funded project with the Fraunhofer network and TICs in Finland, France and Norway. This is an area where UK business and TICs are widely perceived to underperform when compared to other European nations, although the performance of UK universities is stronger, with UK universities attracting funding of around €700 million a year[19].

18 Final Technical Report Activities of EU member states with regard to the reform of the public research base by the ERA-WATCH NETWORK ASBL Technopolis Group 2 July

19 European Commission, FP7 grant agreements and participants database, Vs 4.0, released 1 November 2009. The UK received Euro 1.348 billion of funding from FP, or 14.6% of total funding. In the period of FP6 (2003-06), the UK received a total of Euro 3.369 billion, or 14.2% of funding available.

Spillover benefits – Intellectual property, spin-outs, skills development

(i) Intellectual Property

The development and commercialisation of intellectual property is an objective of some TICs and networks. It provides a measurable spillover benefit to the firms involved and to society, and is a source of additional funding, although this is not usually significant.

Arnold *et al*[20] note there is a trend for TICs to become more "business-like" and include initiatives to make their staff more "IPR-aware". Intellectual property and commercialisation departments within TICs are therefore now common. These departments often provide support for marketing, and business incubation with angel investment and/or venture capital arms in place, in the case of some, to advise and sometimes directly finance their own spin-outs.

By way of example, ETRI in South Korea registered 3036 patents in 2008, and in the period 2004-08 earned over £130m in royalty payments for the use of technologies it had developed. The Fraunhofer Institutes filed 500 patent applications in 2008, and received €83m from licensing revenues that year, including the MP3 licence (this alone generated €100m of revenue in 2005).

(ii) Spin-outs

Most TICs encourage and support the creation of spin-out companies utilising their technology, as well as providing facilities for other SMEs. AIST in Japan, produces around 12 spin-out companies each year, and in South Korea, 16 companies spun out of ETRI have to date, been registered on the KOSDAQ, the SME Market Division of KRX, the South Korean stock exchange.

Furthermore, in 2008, there were 55 companies within a holding company established by TNO for the part ownership of its spin-out companies. These generated £82m of income, with 6 spin-out companies that became independent of TNO that year, showing a turnover of £45m.

(iii) Skills

TICs with a long history have played a significant role in training and the development of applied engineering skills. This has had a substantial impact on the innovation systems of their respective countries[7], with many having this as a specific objective. However, the role TICs in skills development is implicit in the case others, and comes mainly through the demand they create for technically skilled personnel, who then acquire further skills and knowledge, and then take these skills into business.

The Carnot Institutes host 6,500 PhD researchers while the Fraunhofer Society established a technology academy in 2006 offering Masters Degree programmes to graduates with five years industry experience. In Singapore, a key aim of the TICs is to attract top academics and develop new talent: a key factor in attracting knowledge-intensive industries to Singapore, and in helping local enterprises become more internationally competitive.

Outcomes and Impact

Comparing the effectiveness of TICs around the world is difficult as there are no common metrics. Where there is common branding for a network of TICs however, such as the Fraunhofer Institutes, Carnot Institutes and ETR, there are often accreditation and regular evaluations that must be passed for a TIC to retain the brand. However the measurements are often input related, such as the number of SMEs worked with, and the proportion of commercial funding.

In the case of the Fraunhofer Institutes, revenue generated from industry is one of the main parameters for assessing their value, as external contract and research income is only expected flow where the quality and value

20 Erik Arnold, Kate Barker, Stig Slipersaeter, Technopolis, MIoIr, NIFUSTEP, "Analysis of Public Research Institutes in Europe in Selected S&T fields: historical evolution and future scenarios literature review (revised) 16 August 2009.

remains high. VINNOVA in Sweden allocates 70-90% of its grant in accordance with an institute's turnover[17], and funding for the Carnot Institutes in France is also based on the value of contracts with firms, with a bonus for contracts with SMEs[13].

The long-term impact of TICs on national economies are hard to quantify, although ITRI is inextricably linked with the development of the Taiwanese semiconductor industry and figures for the revenue of high-tech enterprises created under Chinese innovation programmes are impressive with 50,000 enterprises and revenues of £900 billion. Furthermore, commercially successful innovations have received a high profile: ETRI holds the MPEG international standard; and the Fraunhofer Institutes the MP3 patent; both of which have generated significant revenues. More recently, an evaluation of the Carnot Institutes by the French Government in 2009, found them to be enabling better access to the research base, resulting in more exploitation of research.

There are few examples where the effectiveness of a TIC has been found wanting resulting in closure. Singapore has closed down a TIC when a technical barrier meant production would be delayed, and individual Fraunhofer Institutes regularly close sub-divisions within the Institute.

Chapter three:
Current UK Approach

Summary

- Over 50 business focused Technology and Innovation Centres (TICs) have received over £150m in public support since 2008.
- There are a number of examples of internationally competitive TICs with highly qualified staff.
- The TICs have been pro-active in developing and commercialising their IP and incubating and starting-up new businesses.
- There is however no formal process for oversight, coordination, promotion and prioritisation of investment in TICs at a national level to ensure alignment with national technology priorities or strengths.
- The scale of investment is often small and short term, with the role of TICs within the UK's innovation eco-system unclear, and
- In general, public funding provides initial capital investment for infrastructure and equipment, with some revenue funding over a limited time period, usually three years, in some cases extendable to five.

Introduction and Context

The UK Government has provided structured support for innovation and technology development in business for decades, and support for Technology and Innovation Centres (TICs) has been one of a range of policy mechanisms deployed to date.

During the 1930s and 1940s, the UK Government encouraged the establishment of Research Associations that served the needs of specific industrial sectors. These operated on a matched funding model, with government providing equal funding to industry in support of research and technology programmes. Many of these Research Associations were established as membership organisations, to generate more industrial funding, and only provided services to their member companies.

In the post-war period, investments were also made in a large number of Public Sector Research Establishments (PSREs) in a wide range of sectors, including defence, agriculture and animal health, transport and water.

More recently, investments have been made to strengthen the university research base and to support and encourage knowledge transfer activities. UK Universities now generate a significant amount of funding from business, nearly £2.8 billion in 2007-08[21], and the Research Councils have also looked to encourage more commercially informed research through their support for, and the establishment of, academic centres such as Innovative Manufacturing Research Centres (IMRCs).

21 Higher Education, Business and the Community Interaction Survey 2009

In parallel, a gradual withdrawal of public funding from Research Associations saw those that continued change their business models, reducing generic R&D activities in favour of more routine and commercially lucrative laboratory and technical consultancy services[13]. Those that remain are now usually referred to as Research and Technology Organisations (RTOs), and operate on both a commercial and not-for-profit basis. Many of these are represented by the Association of Independent Research and Technology Organisations, AIRTO, which estimates its membership to be around 50% of the "intermediate" sector between academia and the end-users of technology. One of the largest, TWI, developed from a professional association of welders rather than a government initiative. Its funding comes from subscriptions from 2000 member companies in 60 countries as well as involvement in public sector and EU programmes and industrial contract research.

Rationale for TICs and their role within the UK innovation system

In recent times, business-focused TICs have been established with the support of a number of public sector bodies to address the capability gap identified in Chapter 1.

The focus and activities within these TICs can be categorised under two broad headings:

- Technology/capability focused – these seek to develop a specific technology and promote its exploitation. Such TICs are established in response to business opportunity/need (often building on the outputs of academic research) which can enable the development of a technology across a wide platform of applications. Examples include the Printable Electronics Technology Centre (PETEC).
- Sector/market focused – these have been established to focus on bringing together complementary disciplines, cultures and/or parts of value chains with examples including MediaCityUK, which has been designed to provide a purpose-built home for creative and digital businesses.

Public investments in such TICs have been made predominantly by the Devolved Administrations and the RDAs in England, which aim to support TICs as strategic drivers of economic development at a sub-national level.

Investments have also been made at the national level. This is often in response to strategic technology requirements that have been identified, such as the call for investment in nanotechnology resulting from the review by Sir John Taylor in 2002. Government investments are often used to catalyse co-funding for TICs from business and other stakeholders. A recent example of this is the investment in establishing a Bioscience Campus in Stevenage, which will support the life sciences sector by creating a hub for early-stage biotech companies. Funding for this has been provided by the Strategic Investment Fund, GlaxoSmithKline, the Wellcome Trust, the Technology Strategy Board and the East of England Development Agency (EEDA).

A requirement of many of these investments is a business model that places an expectation that the TICs will become sustainable commercial entities in a three to five-year period, largely driven by government funding cycles. While this may be appropriate in some instances, there is limited evidence that points to the rationale for investment and associated timelines being informed by a strategic assessment of the role and value of a TIC in delivering a broader programme of ongoing work, prioritised by the Technology Strategy Board, which has been established to play a cross-Government leadership role in delivering a national technology strategy.

The activities of most TICs do not, therefore, appear to be adequately integrated into the national innovation system and related technology development programmes being undertaken in universities with Research Council funding, or sponsored by the Technology Strategy Board. The sub-national approach to investment also appears to have resulted in highly dispersed activity with potential duplication: for example, the

existence of 8[22] TICs across the UK focused on composite materials.

Furthermore, where funding decisions on TICs are made at a sub-national level, in response to a nationally identified need to develop a strategic capability, this has in some instances resulted in co-location benefits (e.g. with the critical mass of academic capability) being given insufficient consideration. However, where this has been properly considered, as in the case of the Advanced Manufacturing Research Centre in South Yorkshire, co-located with the leading research expertise into materials and metals in Sheffield University, it has proved beneficial, and helped the TIC to attract private sector investment.

Funding

Since 2008, the English RDAs and Devolved Administrations have invested over £150m[23] in supporting over 50 business focused TICs. Additional funding has also been leveraged from partners across wider Government, including more recently through the Strategic Investment Fund.

The initial public sector investment in TICs has typically consisted of a mix of capital funding for the infrastructure and equipment, and revenue funding to cover staff costs; the running of the TIC; and some initial project activity. While there is no standard model for either a TIC or its funding at present, in the majority of cases, the split of funding has tended to be 60% capital and 40% revenue. The scale of the capital investment is usually dependant on whether the TIC requires new infrastructure or is based at, or located within, an existing organisation.

To secure public investment, TICs have generally been required to produce business plans that outline their approach to leveraging private sector funding and becoming commercially viable over a three to five-year period. The prospect of competitively tendered project-based funding from the wider public sector and the EU is often envisaged: however, the plans for such activity beyond the period of the initial investment in a TIC have frequently not taken account of the level of funding required to develop and maintain the capability of the TIC, or its role within the long term technology priorities of organisations such as the Technology Strategy Board and the Research Councils.

In the case of TICs focused on emerging areas of technology, or at an earlier stage of research that is further from commercialisation, such a model has not always been found to be viable. The evidence for this lies not only in the international comparisons in this report, but in independent reviews and from the many contributions to this review. For example, an independent assessment of centres of international and national comparative advantage for 13 selected NINJ technologies in the English regions ('New Industry, New Jobs, the RDAs and industrial activism') in November 2009, recommended that "the RDA Network, with partners, should seek to ensure as far as practicable long-term funding programmes", noting that "the nature of innovation, and especially the inherently long timescales (in policy and budgetary terms) associated with commercialisation, argue for a distinctive approach to longer term funding shared by the partnership."

Government funding cycles have also not supported this need for longer-term investment in TICs. It is worth noting for example that the RDAs can only contract for three years at a time, and even where commitments are made for five years, there are break clauses after three. The final two years of funding are not legally guaranteed, resulting in TICs that are often getting 'up-to-speed' after two years of operation and building a reputation, finding business partners reluctant to commit to projects. This has often resulted in TICs having to focus instead on securing alternative routes to future funding. This is a distraction for the senior management at a crucial time in the growth of a TIC.

22 The UK Composites Strategy (http://www.bis.gov.uk/~/media/BISCore/corporate/docs/C/Composites-Strategy)
23 The scale of investment over the last 10 years is close to £900m

A further weakness has been the scale of funding that has been provided to individual TICs. This is demonstrated by the experience of the Micro and Nano Technology (MNT) Capital Facilities programme launched in 2003. The strong desire to leverage regional funding resulted in the recommendation to create two national centres of excellence, as originally envisaged by Sir John Taylor, being implemented through the establishment of 24 centres. This approach enabled the initiative to start and make progress in a relatively short time, but the funding for centres was widely dispersed, resulting in a failure to concentrate resources at an effective level.

Despite significant commitments of public funding of £54m from the then Department of Trade and Industry, £16m of RDA and Devolved Administration funding, and an additional funding stream of £29m for related research projects, the MNT programme has largely failed to achieve a national impact in this strategic sector. A review commissioned by the Technology Strategy Board and the RDA and Devolved Administration MNT Group, concluded that the investment was thinly spread across a number of TICs, resulting in "sub-critical" activity that compromised the ability of the TICs to achieve a distributed network of world-class centres – the original objective set for the centres. However, the development of open access facilities for business was seen to be undoubtedly beneficial.

It should be noted that despite short-term funding structures, some TICs show the potential to benefit from significant levels of funding, which may be sustained over time. For example, the recently established Manufacturing Technology Centre in Ansty has benefited from:

- £40m investment by Advantage West Midlands (AWM) and East Midlands Development Agency (EMDA);
- Founder industrial members paying annual subscriptions: Airbus, Aero Engine Controls, Rolls-Royce and JaguarLandRover (with a number of other companies showing strong interest);
- Four research partners: Birmingham, Loughborough, and Nottingham Universities, and TWI; and
- Being a key partner in the delivery of a number of strategic programmes including the Rolls-Royce led SAMULET project worth over £45m of Government support.

Similarly, the Advanced Manufacturing Research Centre is a £100m partnership between academia, government and industry. Its initial set-up investment of nearly £6m from central government was supplemented by contributions from Yorkshire Forward, the University of Sheffield, European Regional Development Funding (ERDF) and Boeing, who have also committed to 10 years of investment in research and development at the TIC. It now has a large number of private sector partners, including Rolls-Royce and BAE Systems, who pay annual membership fees as well as contracting research.

Both these examples have business models that seek to leverage funding from a range of organisations, through winning competitive calls for research from the Technology Strategy Board and Research Councils; research projects commissioned by business; and through business subscriptions. This model of funding, where there are sustained programmes of investment from public sector partners such as support for High Value Manufacturing by the Research Councils and the Technology Strategy Board, and there are established industry partners capable of paying subscription fees appears to have a greater chance of being sustainable over the long term when compared to models that are dependant on a single initial investment by the public sector.

Governance and Networking

To date, investment in TICs in the UK has taken place with the aim of developing competitive advantage in emerging technologies, or in support of specific strategic sectors and associated supply chains. However, as noted before, decisions on the funding of TICs have largely been made against priorities identified at a sub-national level, with decisions on location

being taken with limited co-ordination across funding bodies and engagement of the private sector and other stakeholders.

This process has resulted in each of the funders assessing the impact of their own investment, with no formal mechanism by which the portfolio of TICs is overseen or formally coordinated at a national level. This is a weakness in the overall UK innovation system and sits in marked contrast with recent efforts to create critical mass and coherence through joint working between the Technology Strategy Board, RDAs and the Research Councils so that UK business has greater clarity and is better able to access the most relevant support available.

In addition, the aim of making TICs self-funding and withdrawing public support at the end of the initial period of public investment has driven decision making based on the need to secure funding and has in some cases resulted in competition between TICs where there are technology overlaps.

The relationship of individual TICs to one another and the wider academic base beyond the locality in which a TIC is based, has also been poorly articulated. However, there are some signs that this specific weakness has been recognised, with measures being put in place to address this, such as the memorandum of understanding between PETEC and four university based centres[24].

International Role

As noted in the International Chapter, TICs have an important role to play as attractors of inward investment and as focal points for demonstrating the innovative capability of a country. They can also access funding and support wider UK business involvement in European and international R&D programmes, such as the EU Framework Programme.

At present, the expertise that exists in TICs in the UK is largely invisible to an overseas audience. Potential overseas investors may know of the existence of TICs within their specific domain of interest which have international standing, but not of the wider complementary capability.

To build on the attractiveness of the UK as a location to invest, which the excellence of the research base has provided, it is vital to drive home that advantage and ensure that the UK maximises the potential from building an internationally leading set of TICs. Inward investment in research and development is often the starting point for further, larger, investments.

Increased visibility and longer-term funding will also improve the likelihood of TICs securing increased UK involvement in international collaborative research projects. TICs also have the potential to increase UK business involvement in the EU Framework Programme which is currently low compared to the likes of France and Germany, by helping to co-ordinate UK involvement. Where the existing RTO network fulfils this role, there are demonstrable benefits.

Spillover benefits – Intellectual property, spin-outs, skills development

Some of the more established TICs have been successful in exploiting the outcomes of their research activity, allowing both more companies to benefit from the research and wider benefits to emerge. For example, the UK's established RTO network makes an important economic contribution to the UK, by undertaking R&D to the value of around £400m each year, and employs 22,000 skilled people, 60% of whom are qualified to degree level or above. It also supports a further 40,000 jobs[25]. Of these, TWI, for example, has 157 granted patents on its books, with its income from licensing activities exceeding £1.8m in 2008.

More recent investments such as that in the Centre for Process Innovation (CPI) have

24 Plastic Electronics: A UK Strategy for Success (http://www.berr.gov.uk/files/file53890.pdf)
25 2006 figures, taken from a report by Oxford Economics for the Association of Independent Research and Technology Organisations (AIRTO), May 2008.

resulted in 11 spin-out companies and 14 filed patents since its establishment.

Many of the TICs have also been successful at attracting a high calibre of staff with expertise covering the relevant breadth of scientific expertise and business experience. However, long-term funding uncertainty does impact on the ability of these TICs to retain staff beyond the original period of funding.

In addition, while there is some evidence of people exchange between TICs and the academic and business base which they serve, there is currently no clear framework to facilitate such exchanges. Where mechanisms do exist to facilitate the exchange of people such as those provided by the Research Councils and Technology Strategy Board in the form of Knowledge Transfer Partnerships, for example, there is currently no systematic approach to ensuring such flows and the development and transfer of skills through TICs.

Outcomes and impact

There is currently no overall framework of criteria and metrics for measuring the performance of TICs in the UK, and to assist in the benchmarking of their performance.

The RDAs have for example developed criteria for assessing investment decisions into TICs, which include the economic relevance of the TIC to the regional and national economy; the ability of the TIC to engage with business and the research base; and evidence of collaborative relationships that bridge business and academia (including the Technology Readiness Levels the TIC will operate across). A number of core outputs with respect to the performance of the TICs are then measured including the number of businesses created; businesses supported; jobs created; jobs safeguarded; and interactions with the knowledge base.

Performance measures are therefore currently set for individual TICs by the organisations providing funding with no reference to a national template[26]. This is in contrast to the Fraunhofer Institutes in Germany and the Carnot Institutes in France, or the accreditation process which is applied to the GTS network in Denmark, where there are consistent performance criteria applied.

This does not however mean that there have been no successes. The New and Renewable Energy Centre (Narec) which has received £30m of investment over the past five years from One North East is recognised in the renewable energy industry as one of the lead centres of excellence worldwide for offshore wind technology development and provides employment for 115 people, many whom have graduated from the region's leading universities. It has major clients in Europe, Asia Pacific and the US and international R&D collaborations in 10 countries. It was also appointed technology advisor to The Crown Estate in relation to the Offshore Wind Round 3 programme in 2010 and by the end of 2011 will have the largest onshore physical test asset base in the world constructed at a cost of £100. It has played a part in attracting inward investment including Clipper Wind's $65m offshore wind turbine development project.

Furthermore a number of the UK TICs considered during the course of this review are at too early a stage of their development for meaningful impact assessments to have been made. However, the MNT review has rightly argued that while the business model of being sustainable within three to five years has been suitable for near-to-market technologies such as Micro-Electro-Mechanical Systems (MEMS) and Microfluidics, it had not provided a stable basis to encourage long-term development of nanotechnology in the UK.

26 The Technology Strategy Board, RDAs and Devolved Administrations are currently working together to develop stronger selection criteria and metrics.

Chapter four: Conclusions and Recommendations

Introduction

Structured government support is an important element of the innovation system. It can facilitate the development of new technologies, help establish them in the market and encourage their adoption, drive economic growth and deliver other spillover benefits, such as the development of new skills.

One of the mechanisms by which government can support technology development is through its investments in Technology and Innovation Centres (TICs) that act as the bridge between research and the commercialisation of new ideas by business.

The innovation systems of all of the OECD economies are characterised by a variety of non-university research organisations. These organisations perform tasks that business and universities, left to their own devices, often cannot or will not perform in sufficient quantity and/or quality. They account for significant shares of R&D performance, both in applied R&D and in fundamental research, estimated as 40% of publicly funded R&D in the EU and about 14% of all R&D[27].

The Fraunhofer Institutes in Germany, ITRI in Taiwan, and ETRI in South Korea, for example, demonstrate how new markets can be established, or significant economic gains achieved, through this model of investment. However, the role of TICs and funding models vary with the national context.

The UK has made significant investments in a variety of TICs, both small and large scale, and national and regional in scope. It also possesses a network of independent RTOs in the private sector. Some of these could have the potential to fulfil a similar function and deliver comparable benefits to the TICs established by our international partners.

However, the approach taken to establishing and investing in TICs in the UK does not currently have clear prioritisation, long-term strategic vision, or coordination at a national level. Furthermore, mechanisms for identifying the sectors or technologies which would benefit from such support and an approach to selecting the national TICs with a formal role for the Technology Strategy Board, does not currently exist.

This is the case despite the Technology Strategy Board's broader role to develop and deliver a national technology strategy, and its funding of Knowledge Transfer Networks (KTNs), which work closely with business and academic stakeholders to provide information about developments, opportunities and the needs of, specific areas of technology.

The current UK approach has therefore often resulted in sub-optimal and dispersed investments with the lack of long-term funding certainty damaging the ability of TICs to: engage with business; realise the full potential of their assets; invest in long-term capability; recruit and retain the best staff; and commercialise leading edge research.

This compromises the ability of the UK to establish or build on existing capabilities. It also makes it difficult to provide business with information about the TICs which exist, assure them of the quality of their service and enable access.

In the face of increasing competitive pressures, there is an urgent need for the UK to make

27 European research Advisory Board Final Report – Research and Technology Organisations and ERA (December 2005)

difficult choices and focus its attention on exploiting those areas of strength and capability where there are global market opportunities, to ensure future prosperity. To do so, it is critical that it has business-focused TICs that have national focus; sufficient funding to reach critical mass; and are better integrated into the national innovation system to deliver the new industries and jobs of the future.

The variety of structural, institutional and cultural differences that inform the role and operation of TICs overseas means it would not be sensible to transplant a particular model and seek to replicate this in the UK. Therefore, the aim of this review has been to identify the factors behind the success of TICs and networks of TICs overseas, and to use these to develop a model suited to the diverse innovation system of the UK.

The recommendations below propose a new approach to investing in TICs with a national remit. They call for investment to be focused on an elite group of TICs and embedding these more firmly into the UK's innovation system, and maximising their effectiveness as a bridge across the process of technology development and commercialisation. The recommendations also focus on enabling business to access the depth of technology expertise that exists in these TICs, to reach through to the excellence in the research base, and to access global networks of relevant expertise.

Mission and Strategy

The mission of TICs is to help bridge the gap between research findings and outputs, and their development into commercial propositions through the provision of a business-focused capability that enables companies to share the costs of R&D, access skills and equipment which might not otherwise be within their reach, and so reduce risk, shorten time to market, and exploit synergies of know-how across the value chain.

The UK currently has a strategic gap in its approach to investing in TICs which can play a key role in supporting the development of new technologies in areas where the following conditions prevail:

- the potential global markets are predicted to be worth billions of pounds per annum;
- the UK has truly world-leading research and potential business capability and absorptive capacity to make use of increased investment;
- the UK has the ability to capture a significant share of high value activity; and
- TICs can enable the UK to attract and anchor the knowledge intensive activities of globally mobile companies.

There are already a number of candidate technology areas in the UK that potentially meet all these requirements, including, stem cells and regenerative medicine; future internet technologies; plastic electronics; software & technologies addressing renewable energy and climate change; satellite communications; fuel cells; advanced manufacturing; and composite materials, amongst many others.

However, in a resource constrained environment, difficult choices must be made to ensure sufficient support is provided to a small number of mission focused, elite, national TICs, focused on technology priority areas. Like many highly successful TICs abroad, the UK can use this prioritisation to capitalise on national strengths rather than support a wider spread of activity in many technology or sectoral fields.

Recommendations

1. The UK Government should commit itself to establish, and provide sustained funding for a network of elite business-focused national TICs in areas where the UK has the potential to gain substantial economic benefit.

2. Government and the Technology Strategy Board should work with stakeholders across the private and public sector and publish a national strategy for the TICs including:

    - setting a vision for their development over the next ten years. This should cover the role of TICs within the UK innovation system;
    - criteria for establishing these elite TICs;
    - the provision of public funding for them;
    - achieving better co-ordination of the elite network of TICs, and
    - their engagement with the wider science and innovation system in the UK and internationally.

Investment decisions being taken by a wide range of local, regional and national bodies is also a major weakness in the current UK approach. It results in dispersed funding and insufficient attention being paid to the location of critical mass of research expertise, and business capability. This can inhibit the exchange of know-how and tacit knowledge, as well as the development of active collaborations, which are facilitated by co-location.

Recommendation

3. When establishing new TICs, or enhancing and building upon existing TICs, decisions on their location must pay due consideration to their national nature, track record, the location of UK research excellence (in universities and elsewhere), alongside industrial capability and absorptive capacity.

Funding, Staffing and the Role of Procurement

TICs funded by the UK's international competitors benefit from sustained and predictable flows of public funding, often with a view to capitalising on local and national strengths.

International TICs also benefit from a variety of complementary sources of funding that combine core public sector funding for infrastructure and capability building, with programme and contract funding from the public and private sector.

A more strategic and sustained approach to the provision of funding for the national TICs would benefit the UK. This will help integrate these TICs into the wider innovation system and the programme of technology focused activity that is supported by the Technology Strategy Board and its partners across wider Government.

Furthermore, given the nature of research and the time to fully capitalise on its outputs, a dedicated and 'fit-for-purpose' funding stream must be established, to enable long-term planning that maximises the contribution of these TICs in delivering a programme of activity.

The UK has in recent times begun to adopt a sensible long-term approach to supporting programmes of work through the Technology Strategy Board led Innovation Platforms that are focused on addressing key societal challenges. These Innovation Platforms are

established following extensive consultation with stakeholders resulting in a well defined programme of work focused on a technology roadmap, with earmarked funding, that runs over an initial five year period.

Such a model, providing long-term vision and certainty, will address many of the weaknesses associated with the current approach that only sees short-term revenue funding for TICs with unclear expectations as to their role within the wider system, alongside unrealistic expectations on their ability to sustain activity through private sector income alone.

Recommendations

4. Core funding for each of the TICs must be properly costed, with the duration of funding consistent with delivering a wider programme of work prioritised for support by the Technology Strategy Board, Research Councils, and partners across Government. It must also take into account industry needs.

5. Funding must be sustained well beyond the current three year Spending Review periods and be of the order £5-10m per annum per TIC, over on average, a 10 year period (subject to review), to deliver meaningful benefit. This should build on the model developed by the Technology Strategy Board for funding Innovation Platforms, which co-ordinates the investment of a range of funding bodies to maximise the impact of public and private investment.

The strategic approach to the provision of core funding should also seek to integrate and capitalise on the work and excellence of the UK's research base so as to remove duplication and increase co-ordination between TICs.

Recommendation

6. Funding should incentivise the TICs to link with and draw upon the outputs of the research base and other TICs. This should include the requirement to minimise duplication by commissioning work from the research base where appropriate.

Core public sector funding should not be the only source of income for the TICs, however. Their in-house capability and capacity must be such that it attracts and leverages significant private sector contract income, alongside grant funding from EU and national programmes. A workforce drawn from the academic base and private sector that possesses research, technology development and commercialisation skills is recognised by many international TICs as providing the range of capability needed for their role. Some use secondments from universities and industry to maximise technology and skills transfer.

The UK has structures in place to facilitate such a transfer of knowledge, in the form of Knowledge Transfer Partnerships (KTPs) for example, which also enable the development of individuals with the necessary future skill sets. The use of such schemes must therefore be designed into the TICs to ensure the relevant flow of people and the transfer of skills through TICs.

Recommendation

7. TICs must be established with a view to attracting highly networked and trusted managers and staff with relevant business and technical skills. Each TIC should also develop the skills of the people they employ and an active secondment programme with academia and industry should also be established.

Matching technologies to markets is a key process for successfully commercialising technologies, in particular breakthrough technologies. The scale of government, and other public sector procurement, means it can play a major role in providing a market for emerging technologies. The benefit is clear to the government procurer in obtaining innovative solutions, but this also represents an efficient use of government money due to the effect on the UK economy of this innovation.

Given the role TICs will play in helping companies develop demonstrators and establish supply chains, procurement mechanisms such as Forward Commitment Procurement and the Small Business Research Initiative (SBRI) could become a critical component in both the funding and success of these TICs.

Recommendation

8. The Government should build on a number of successful innovation procurement initiatives, such as the re-launched SBRI programme, the Forward Commitment Procurement programme and the NHS National Innovation Centre. Public sector organisations should also be encouraged to run procurements in technology areas in which TICs are active, to help create the demand stimulus for commercialising these technologies.

Governance and Networking

International examples have shown that a strong governance structure is critical to ensure strategic direction and the quality of services provided to business. It is also important to ensure the linking of activities within TICs and with those across the wider innovation system, and to co-ordinate public sector investment in TICs to ensure the greatest impact.

The role of the governance mechanism will also be to maintain focus and ensure the relevance of activity, across the network of elite TICs to monitor progress and only maintain funding on those technology areas offering the best long term growth opportunities for the UK.

Individual TICs need to operate with a high level of autonomy, to give them the flexibility to respond to business needs and market opportunities. They need to build strong relationships with both business and academia, and with other institutions active in the technology area they operate in. Their own governance arrangements should reflect the need to draw on academic and business expertise to provide guidance on all aspects of the work at the TIC.

Recommendation

9. The programme of activity in each of the national TICs should be overseen by a business led steering group, comprised of business and academic experts in the technology.

10. The Technology Strategy Board should establish a new UK Technology and Innovation Centres Management Board charged with overseeing the network of national TICs, drawing on suitable representation from industry, the research base and wider Government. This group will publish an annual report on performance of the network and will also be responsible for prioritising future investments and monitoring the overall UK strategy for TICs.

Marketing and International Collaboration

The diversity of the UK's innovation system creates difficulties for businesses and inward and private investors to identify key capabilities in the UK, and be assured of the quality of the technology development being undertaken in TICs. It also compromises the UK's ability

to effectively market this element of the innovation system within the UK and overseas.

As noted before, international best practice suggests a strong brand can reinforce a TIC or the network of TICs by making them a more attractive partner to the private sector and for international collaborations.

Recommendation

11. The Government should consider the value of a unique brand for these elite national TICs, which recognises their core role in the UK's innovation system. This could help clearly articulate areas of national priority to both UK businesses and promote the UK's innovation offer overseas. The brand should recognise and commemorate a significant UK contribution to science such as the work of James Clerk Maxwell whose unified theory of electromagnetism is the basis of the whole IT industry.

12. The Government, in conjunction with the Technology Strategy Board, should also create a web-based database of TICs and related institutions offering services to business. This should be available through the BusinessLink website, and accessible from the websites of other public sector organisations.

Finally, there is also strong evidence that international collaborations strengthen the quality of research undertaken in TICs. Collaborations are also the route to accessing potentially significant funding streams, such as the EU Framework Programme.

Recommendation

13. The joint BIS/FCO Science and Innovation Network, and UK Trade and Investment should work together with relevant organisations in the UK, to develop an offering that can support UK businesses seeking to access world leading expertise in TICs overseas, particularly in the EU. This will build on UKTI's existing provision for "born global" companies in high-tech sectors such as life sciences.

14. The Technology Strategy Board should work with UKTI and the Science and Innovation Network to promote the existing network of UK centres to businesses and similar centres internationally, and in particular, help the UK's national Centres develop international links and attract inward investment and funding.

Annex A:
Terms of Reference

The review will examine and make recommendations to Government on the current and future role of technology and innovation centres, which provide services to business, as part of the innovation system of the UK. In particular, the review will consider:

- the role of existing technology and innovation centres in the UK including
  - potential duplication
  - gaps and opportunities for new centres in technology areas where the UK has particular strengths;
- the role of technology and innovation centres as part of the overall innovation system including
  - how they can be best used for the benefit of business
  - how they relate to other organisations such as the Research and Technology Organisations in supporting business;
- benchmarking UK outcomes against overseas comparators, including Germany and the Netherlands
- EU and international best practice examples, such as the Fraunhofer Institutes and the Delft Centre, and how the learning from such examples translates to a UK context;
- how technology and innovation centres contribute to the generation of commercially useful intellectual property;
- the role of technology and innovation centres in supporting the development of early stage companies emerging from business or the research base;
- the need for a national strategy on centres and how decisions should be made in future on the location of new nationally significant centres; and
- how the centres in the UK could be better co-ordinated and promoted as a group to both increase awareness to UK business and also to demonstrate UK capability to attract inward investment and collaboration.

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