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From:

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Introduction

This response to the BIS 2014 Science and Innovation Strategy Consultation is from AIRTO (The Association of Innovation, Research and Technology Organisations). It summarises AIRTO's contribution to the workshop held with BIS at the Royal Academy of Engineering on 15 July 2014.

AIRTO's members present at the workshop included representation from:

- Public Sector Research Establishments (PSREs);
- Non-profit distributing member and non-member based research and technology organisations (RTOs);
- Privately held research and technology companies (including Contract Research Organisations - CROs);
- University Enterprise/Technology Transfer Departments;
- R&D departments of industrial companies;
- Business support organisations (including those offering Access to Finance support).

All AIRTO's members are engaged to a significant extent, and in various different ways, with the translation of new ideas, research outcomes and technological advances into innovative products[1], both for commercial markets and public services. Their work is undertaken both for businesses and industrial clients responding to market pull, competitive pressures and evolving regulation by introducing new technological products, and for clients exploiting research to create new offerings and new markets for technology. As demonstrated by the new Oxford Economics study due to be published shortly, this contributes significantly to the UK's economic growth.

Innovation – what is it and what do AIRTO's members do?

INNOVATION in the context of this discussion is the translation of new ideas into successful products (and services). The TSB defines innovation as "the successful exploitation of new ideas - because it drives economic growth".

AIRTO's members provide the professional scientific, technical and business support essential for those wanting to explore new ideas and introduce innovative developments for their businesses and operations for all the reasons outlined above. There is a strong emphasis on the practicalities of implementing innovation programmes. Members provide access to essential skills, experience, facilities, development capacity and training, including providing assistance with obtaining finance, and culminating in proving compliance with regulation and standards and at scale demonstrations of performance and benefit to end users. These work programmes are part of the progressive risk reduction that has to take place between TRLs 3 and 7 on the Technology Readiness Level scale, whether the original idea and technological innovation comes from a business or from academic research.

Most members have varying degrees of interaction with both private and public sector clients and sponsors for their work. The balance and type of involvement varies from member to member according to need, circumstance and availability of finance.

The Innovation Sector – what is it and what is AIRTO's role within it?

The INNOVATION SECTOR comprises professional organisations and companies which supply the essential specialist services required to realise innovations as successful value adding products, services or processes in the commercial marketplace or within the public sector. As noted above, these services include relevant activities in applied research, design, development, technology translation/adaption, testing, proving, project management and

[1] In this context, 'products' includes new technologies and technology enabled services.

financing. These services generally lie between TRL 3 and TRL 7 on the Technology Readiness Level scale. They add value by bringing to bear the necessary combination of professional attitude and approach, skill set, experience and specialist facilities which AIRTO members specialise in providing.

Client needs for these services vary sector by sector and according to circumstance. Therefore the various organisations that comprise the Innovation Sector specialise in different types of work and different areas of application; some specialise in serving particular industries (e.g. automotive), others in providing expertise in particular technologies (e.g. composite materials), others in tackling particular multidisciplinary challenges (the various Catapult Centres for example) and some provide support for business processes (e.g. planning, staff development and risk and project management, in the particular context of innovation).

The innovation sector therefore embraces the community of organisations that play an essential role in embedding advanced technologically based developments in commercial or other forms of product for end user uptake. AIRTO is the membership network for these organisations. AIRTO's network helps members to stimulate innovation, develop and exchange knowledge and best practice between organisations and foster connections between business, academia, sources of finance and government.

Headline areas for Government action

There are significant risks involved in carrying through innovation programmes. Working in the innovation sector where new cutting edge technologies are continually being introduced requires partnership between public and private sectors. The challenge for BIS is to mitigate the risks involved in adopting new technologies and first use of innovative developments to the point where private finance has the confidence to take on the remaining risks and commercial exploitation. Spanning the TRL gap (or 'valley of death') from a policy perspective is therefore a matter of creating an appropriate and well-balanced 'public/private partnership'.

In this context, for the sector to function efficiently and maximise contribution to growth, two things are required from Government:

1. Assistance with replenishing physical and intellectual capital as established technologies are transferred to industry and new leading edge technologies move ahead. Without renewal of capital facilities and associated skills in this TRL 3 to TRL 7 domain (and beyond the capital resources required by universities for their research) it will not be possible for the UK to exploit fully the fruits of its investment in research and industry will be at a disadvantage in terms of its ability to test and demonstrate new, competitive and innovative products, services and technologies.

2. Application of the leverage available through the purchasing power of public sector procurement to pull through innovative products and services into every-day use. Providing purchasing contracts, to innovative SMEs in particular, will to help raise the level of private investment in r&d and thereby increase SMEs' resources for growth and job creation. SBRI should be used more extensively for this purpose, with placement of procurement contracts for research through to supply of demonstrators and prototypes. R&d tax credits will further incentivise innovation and should be made widely available, but they are not a substitute for procurement initiatives as they do not provide such a direct underpinning for investment decisions.

Britain's innovation organisations

Britain has a large and thriving innovation sector, which contributes significantly to our national capabilities[1]. The organisations that AIRTO represents are a significant component of the UK's innovation ecosystem employing over 40,000 scientists, engineers and technical staff, comparable in size to approximately twenty research

intensive universities. A current study underway by Oxford Economics, for completion later in 2014, indicates that the members from this sector that AIRTO represents have a combined turnover in excess of £5.5 billion, over three times the size of the Fraunhofer institutes in Germany. The primary objectives, strengths and capabilities of the innovation sector are centred on the introduction of new technology into commercial products and public services. In its' 2011 'Innovation and Research Strategy for Growth', BIS recognised the UK's sector as an 'under-utilised asset'[2]. AIRTO welcomes the consultation that BIS is undertaking with stakeholders to review the Government's science and innovation strategy, particularly in regard to the constituents of the innovation sector.

AIRTO's input to the Science and Innovation Strategy 2014

AIRTO's response to the specific questions posed by BIS at the workshop is as follows:

Q1. Business investment and performance: - how to close the R&D investment gap with our competitors and bring business innovation in products and services to the level of other leading economies.

1.1. Britain has numerous universities represented in the top 50 institutions world-wide, partly reflecting the strong level investment in early stage research (technology readiness levels 1-3), competing well against nations like Germany. Closing the R&D investment gap with competitor nations can only be achieved if the UK does more to tackle the need for more investment in mid-stage R&D (technology readiness levels 4-7). There are in reality two principal challenges within the end-to-end process of commercialising scientific and technological research that, taken together, constitute the so called 'valley of death'.

1.2. The first such area is the industrialisation of the research results themselves i.e. turning the outputs of work aimed at the generation of new knowledge into fully understood technology that will be capable of surviving and operating in the challenging user environments required by commercialisation. This adaptation to harsh user environments, such as those found on production lines, in transport systems, in the natural environment, in space, on the battlefield and even in the home, just to cite a few examples, is beyond the remit and capability of most university laboratories that often lack the requisite infrastructure. (RTOs on the other hand do often have access to requisite infrastructure and could be better utilised in this regard). Those engaged in commercialisation frequently do not discover what is unknown about the technology until they start the process of industrialisation. Additionally, in many instances, challenging cost targets for the eventual product or service have to be met. This is a risk both to those who are taking on the process and those who are financing it.

1.3. The second area of challenge is the process of defining and implementing a competitive business model and the execution of a viable business plan. The risks here include uncertainty over eventual take-up in the marketplace, reaction from competitors, ability to assemble a management team and changes in general economic conditions, amongst other things.

1.4. The main difficulty in approaching the 'valley of death' is overcoming the perceptions of those financing a commercialisation (be that industry licensees, early stage venture capitalists, lenders or in-house "sponsors") that the risk of losing their investment is too great. This is frequently compounded by a significant communication barrier between innovators and investors (or those responsible for making investment decisions). The innovators frequently don't understand the language and fears of investors, particularly those from the private equity and venture capital domain, and the investors don't have the knowledge or tools to properly evaluate the development risks or market diffusion potential of innovative technology, unless it is pretty obvious.

1.5 Innovations based on the adoption of new technology very frequently originate in business and industry. Encouragement and support for these opportunities should not be neglected. The challenges of take-up and finance for them are frequently as great as those encountered in the exploitation of academic research. AIRTO members, by the nature of the work they do, are very familiar with this domain and the difficulties that companies face in carrying through their innovation programmes. AIRTO is very keen that everything possible should be done to help companies ensure that they are adequately financed and therefore able to invest in additional r&d. The remainder of this section therefore focuses on what might be done to facilitate access to finance for investment in r&d.

1.6. Summarising the above, the main uncertainties creating perceptions of risk for any given commercialisation opportunity are generally that:

- the market need remains unproven;
- the intellectual property is not sufficiently protected or secure;
- the appetite for the proposed innovation in the supply chain providing the route to market is unclear;
- there is not a credible team to manage the commercialisation;
- expensive (and possibly unknown) technology development issues may remain which will have to be tackled and which will require additional time and finance to resolve;
- very early stage investors may find themselves at significant risk of extreme dilution in later rounds of investment in a new venture. This is particular acute with long timescale developments, which are typical of, for example, the biotech sector.

1.7. These problems are compounded by:

- communication difficulties and lack of mutual understanding between innovators and investors;
- insufficient availability of financial resources to follow on from research with de-risking 'proof of concept' activities;
- insufficient availability of management expertise with experience in early stage commercialisation;
- insufficient availability of financial resources to support skills development (including human resource skills) amongst aspiring entrepreneurs. This is a significant challenge given the variety of perceptions and attitudes found amongst researchers to commercialisation of their work;
- uncertainties over the size of investment required, the likely magnitude of the eventual return and the timescale required to obtain that return.

1.8. Such difficulties can be overcome by increasing efforts to raise levels of investor confidence prior to moving on to complete reliance on mainstream privately sourced development effort and finance. This can be achieved by:

- utilising the purchasing power of public procurement wherever possible to pull through innovative developments by placing first use contracts, with entrepreneurial SMEs in particular, and expanding the use of SBRI for such purposes;
- utilising r&d tax credits to offset some of the risk and to improve the likely return from early stage private investment in r&d;
- continuing the support provided through programmes such as the forthcoming Business Coaching for Growth programme from BIS, particularly the investment readiness and investor readiness components;
- increasing support for pre-commercial 'proof of concept', seed stage equity and loan funding (probably with a combination of public and private sector provision);
- making more use of post-research incubation capacity and assistance, especially that which facilitates access to harsh user environments, potentially available through RTOs (as recommended in the recently released BIS Research and Innovation Strategy), including the new Technology and Innovation Catapult Centres;
- reducing excessive dilution risks for very early stage investors by providing liquidity for such very early stage investments, particularly those in longer term developments, possibly through new specialist secondary funds. This will also avoid premature loss of support from public sector financing and avoid excessive dilution of early stage public sector investments, as experienced by previous Early Growth and similar government supported funds.

Q2. Infrastructure: striking the balance between the needs of individual institutions and investment at the national and international level and looking to improve the effectiveness and cohesiveness of the existing research and innovation infrastructures.

The UK should adopt a three pronged approach, dividing its capital investments into three approximately equal and ring fenced sub-funds, to ensure the availability of adequate resources on a continuing basis to underpin:

a) global pre-eminence in curiosity driven and fundamental research;

b) continuity of participation in long-term international collaborations (e.g. space);

c) campaigns to apply and exploit ground breaking new science and technologies as they emerge (e.g. graphene);

The UK needs to plan for both project and institutional investment which helps to translate scientific discovery into national benefits in a timely manner.

Responsive mode funding which is available at present is not, in the main, strategically 'joined up'. Adopting more of a challenge-led, 'road map' based approach (although complex to achieve and implement) is the most effective way to enable a strategically joined up investment approach to be implemented for the long-term. Approaches currently employed by the MRC and EPSRC reveal some good examples of how this can be achieved. Adopting a challenge-led approach is also beneficial. It can connect various otherwise individual projects at a range of Technology Readiness Level (TRLs), supporting enhanced exploitation between academia and industry. Britain's research and technology organisations (RTOs) play a key role in such multi-disciplinary collaborations and can stimulate new more fundamental research projects by linking researchers to challenges in the field. Societal challenges such as 'efficient resource use' or 'resilience' are good examples – requiring a mix of multi-disciplinary engineering and more fundamental science.

At the same time a reasonable proportion of the total funding should continue to be made available for individual academics to underpin a critical mass of 'blue skies' research.

Strategic decision making bodies have to prioritise over 10 year or longer timescales to ensure continuity of participation in international programmes which enable the UK to remain a global player in major scientific and engineering advances e.g. at CERN and in Europe's Space Programmes. A particular issue in planning commitments for UK participation in such large international programmes is the need to factor in allowance for fluctuations in currency exchange rates and to avoid 'raiding' funds intended for national programmes when rates move against the UK.

Likewise, some headroom needs to be provided to enable the UK to respond to application opportunities which need investment in capital infrastructure in order to embed new scientific advances and technologies within the innovation ecosystem, both within and beyond the universities. Priorities in this area need to be responsive to signs of emerging potential and uptake within industrial and commercial applications. Investment capacity needs to be managed to ensure that the UK has the ability to follow up with development of the application infrastructure without undue delay. Decisions around such emerging, near term opportunities need to be made on a case by case basis, in the context of:

• the relative strengths and weaknesses of the UK's innovation infrastructure (i.e. existing national capabilities and expertise mean that inevitably the UK is better positioned to respond and perform with regard to opportunities in aerospace, transport, agri-food, pharmaceuticals and other priority industry sectors);

• the case for return on investment (both short-term and long-term);

• the potential for societal and humanitarian impact;

• the capacity of the UK to bring emerging technologies to market and compete;

Overall, this means balancing the long-term need for the UK to remain committed in international collaborations and fundamental science with the imperative of obtaining an economic and societal return on investment. This balance should reflect the fact that the costs of developing, engineering and exploiting technology in most instances far outweigh the costs of the initial research, but recognising also that beyond the capital infrastructure needed to support exploitation, private sector interests should be able to finance much of the applications work required.

The capital infrastructure needs for these application activities extend beyond the universities across the entire research and innovation sector. Given the breadth of requirement for capital investment through most of the stages of encompassed by the

TRL stages, it seems clear significant prioritisation will be necessary in terms of which industry sectors, applications and emerging technologies to support. The BIS industrial and 'great' technologies strategies are therefore to be welcomed. Without such concentration on key areas it is inevitable that resources will become too thinly spread and disjointed to provide an effective return on investment.

The rationale for suggesting three approximately equal categories of international, basic research and application capital spending is that

a) the international programmes deliver attractive incentives for people to take up careers in science and technology and the develop advanced engineering skills and capabilities that have widespread application;

b) fundamental science is a UK strength and provides early sight and a knowledge base in advances that may have a major impact in the future;

c) applications of new advances in a sustained and well-coordinated manner is crucial for the UK's economic prosperity and for generating the returns needed to pay for investment in the categories above and for continuing application development. The infrastructure needed to underpin such applications requires equipment and facilities for independent testing, validation, accreditation and demonstration of new technologies and systems.

It is hard to see that any one of the three categories should be less generously funded than the others without risking damage to the continuity and capabilities needed for UK scientific and economic success in research and innovation.

Q3. Talent: How to expand the number of people in STEM disciplines at all levels and to raise awareness of the opportunities for science careers and developing a better understanding of the balance of skills and disciplines we will need for the future.

BIS could usefully raise the profile of STEM related career opportunities in PSREs and other non-university research and innovation establishments. In years past STEM graduates, for example, would have been able to contemplate careers in PSREs, RTOs, and corporate research laboratories as well as in industry and universities. More recently the corporate laboratories have largely disappeared and other non-university establishments have largely dropped out of sight, with respect to graduate recruitment. Promotion of Government owned and Government supported research and technology organisations as potentially rewarding career paths could well help to increase the number of people attracted to STEM disciplines. AIRTO would be delighted to work with Government on a campaign with this objective.

AIRTO members build their businesses around the application of innovative ideas and technologies for a broadly defined client base. They are therefore particularly dependent on being able to recruit versatile scientists and technologists. Potential recruits must have an interest in both science and technology and its application both in business and elsewhere in the economy and society.

To develop a pipeline of potential talent, many members, including organisations like ARUP, AWE, BMT, BRE, MIRA, NPL and QinetiQ , already operate apprenticeship, graduate or postgraduate development schemes, and a number are involved in schools outreach, with most offering work experience opportunities and/or internships to young people. About half of AIRTO members work with higher education institutions to deliver training. Examples of this include TWI's Structural Integrity Research Foundation (with UCL and Universities of Brunel, Manchester and Cambridge), the BRE Trust (with Universities of Cardiff, Bath, Strathclyde and Edinburgh) and NPL's emerging metrology partnership with Universities of Surrey and Strathclyde. RTOs tend to have a very broad client base, which includes businesses from diverse sectors, industries of widely differing types and public sector organisations of various kinds, supported by extensive contacts with academia, financiers and funding bodies. This provides an ideal environment within which to develop a rounded skill set; only really large corporations are able to offer anything comparable, and then generally only in the context of tightly channelled commercial interests.

More Government intervention is needed to capitalise on the sector's capabilities to develop skills. A particular area of interest for AIRTO members is the skill set needed to work successfully on the commercialisation of research. This is an area where there is a clear shortage of people with the multiple skills, including the vitally important 'soft/people skills', needed to deal with this critically important challenge for the UK. An apprenticeship programme for such individuals ideally might comprise a series of secondments, each for a period of six to eighteen months, to academia, the finance sector, departments of government (such as BIS) and commercial industry, much along the lines of a traditional fast track graduate development scheme in a large enterprise. Such a scheme, or a suitable variation on the concept, would require financial support but would quickly produce a younger generation of multi-skilled practitioners ready to carry on the challenge of capitalising on the UK's strong research and

innovation base. The sector would be very well placed to host this kind of programme, working in conjunction with their networks of commercial enterprises, universities and Government departments. This would capitalise on the vital role that the sector already plays in contributing to the development and retention of the UK's skills base by providing scientists, engineers and technologists with:

• professional development of talented graduates and PhDs;

• training through apprenticeships and internships;

• defined career pathways;

• job mobility.

Engaging the RTO sector as a training partner at apprenticeship level and recognising the role the sector has to play in employability of the graduate workforce should be a central component of the government's strategy for better utilising the UK's assets for accelerating innovation.

Q4. Finally, we need to ensure that we have the right balance between curiosity driven and applied research and be better able to identify the technologies that can help drive future economic growth enabling us to Reap the benefits of our investment in research and innovation.

As indicated in our answer to question 2 above, a reasonable proportion of the total funding resource should continue to be made available for academics to underpin a critical mass of 'blue skies' research. This requires balancing the long-term need for the UK to remain committed in international collaborations and fundamental science with the imperative of obtaining an economic and societal return on investment. This balance should reflect the fact that the costs of developing, engineering and exploiting technology in most instances far outweigh the costs of the initial research, but recognising also that beyond the capital infrastructure needed to support exploitation, private sector interests should be able to finance much of the applications work required.

Declaration of interests

This submission is made by the Association of Independent Research and Technology Organisations (AIRTO). The organisation represents research and technology organisations, operating in the space between the academic research of universities and the commercial needs of industry. AIRTO members undertake research and development, and knowledge and technology transfer. This submission does not necessarily represent the views of individual member organisations. (AIRTO Ltd. is a company limited by guarantee registered in England No. 1217006, registered address: National Physical Laboratory, Hampton Road, Teddington, Middlesex, TW11 0LW. AIRTO is a not-for profit organisation funded by membership subscriptions, and managed under contact by NPL Management Ltd.). The members of AIRTO currently are:

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[1] Study of the impact of the Intermediate Research and Technology Sector on the UK Economy; Oxford Economics, May 2008
[2] Innovation and Research Strategy for Growth; BIS, December 2011