

LEVERAGING PUBLIC PROCUREMENT TO GROW THE INNOVATION ECONOMY

An Independent Review of the Small
Business Research Initiative by David
Connell; *Final Report and
Recommendations*

November 2017

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Foreword

Over the last thirty years I have become increasingly aware of the key role played by customer funded product development contracts in the early stages of many of the UK's most successful science and technology based companies. They focus R&D on real customer needs, build credibility and help bridge the *valley of death* between start-up and the creation of a profitable product business. And by providing non-dilutive funding they can make it easier for founders to retain control and grow a substantial UK based business rather than succumbing to investor pressures for an early trade sale.

It is only by looking at the early history of successful businesses that the role of lead customer contracts becomes clear. They have been a key feature of most of the largest companies in the Cambridge cluster, as well as many other global successes, including Microsoft and Intel. Vodafone, the UK's most successful technology based business to be started since the second world war, is essentially a spin-out from Racal, originally set up in a garden shed by two engineers in 1950 to design and supply specialised radio equipment for the MOD.

Lead customer contracts continue to be important for start-ups and early stage companies across a wide range of sectors. There are strong arguments for policies that encourage this practice, both by private sector corporations and by public sector organisations.

The Small Business Research Initiative (SBRI) is designed to do exactly this in the public sector. It aims to increase the **demand** from government departments and agencies for innovation by placing contracts (not grants) for the development of innovative technology solutions that meet defined needs.

It complements the more traditional approach of most UK innovation policies which have tended to focus on increasing the **supply** of innovation through the commercialisation of academic research and subsidies for R&D in the private sector.

At the same time as contributing to the growth of innovative British companies, SBRI also provides a mechanism for improving the cost effectiveness of government departments and public services, and for addressing new challenges in areas like public safety and security. There are barriers to innovation in all mature, large organisations, and especially so in the public sector. SBRI offers a systematic way of addressing these barriers – providing a mandate for the search for solutions and a way of managing risks while they are developed and tested.

This report examines how we can maximise the impact of SBRI; by improving procurement outcomes for government and by supporting and stimulating innovation by SMEs, boosting

the UK's innovative capability, and supporting the development and commercialisation of new technology-based products and services in the UK. The Review was announced by the Prime Minister in her speech to the Confederation of British Industry on 21st November 2016 and is a part of the Industrial Strategy work programme.

I am grateful to the many individuals from government, commercial organisations and industry associations that have contributed to the Review through interviews, workshops and other mechanisms.

The report also draws on observations from my own experience: as a cofounder or participant in new ventures; as a venture capital investor; as a member of the NHS England SBRI Management Board; and from research on new ventures and innovation policies in the UK and elsewhere undertaken with colleagues at the Centre for Business Research at the Cambridge Judge Business School.

Special thanks are due to the excellent core team, led by Stuart Barthropp and Sophie Boldon at BEIS, for their help and advice throughout the Review: they include Yi Zhang (BEIS), Ben Marriott (BEIS), Stephen Browning (Innovate UK), Stephen Tokley (Crown Commercial Service), and John Kenyon (Crown Commercial Service).

David Connell

Executive Summary

Background

The Government's Industrial Strategy Green Paper signalled the most significant commitment to policies to strengthen the UK's industrial base and develop its regional economies for at least 40 years. A key objective is to make the UK one of the most competitive places to start or grow a business, not by 'backing winners', but by creating the right conditions for new and growing businesses to thrive.

The Small Business Research Initiative (SBRI) has a unique and valuable role to play in this context. It works by providing new ventures and SMEs with contracts to develop innovative products that address unmet public sector needs, offering a 'win-win' opportunity for both the public sector and UK businesses alike. For the public sector, it offers a way to gain access to new technologies, products and solutions to improve its cost effectiveness and address policy challenges, whilst supporting a longer term, and more strategic, approach to procurement more generally. For UK businesses, it provides product development contracts from lead customers that are focused on real market needs. It can provide 100% funding in amounts sufficient to have a transformational impact on a company's prospects at a point when other sources of funding may be unavailable or insufficient.

An effective SBRI programme would boost the UK's innovative capability, support the development and commercialisation of more new technology-based products and services, and give more innovators their "first break" and a route to market.

Yet, despite this widely accepted logic and the progress that has been demonstrated so far, the public sector is still not taking full advantage of SBRI's potential. Its use, and method of implementation, varies widely across government, with many departments failing to get engaged in a meaningful way. Indeed, in 2015/16 total SBRI funding fell by 25% compared with its peak the previous year.

The Review Process

My aim in this report is to examine what SBRI has achieved to date and how, and to make recommendations that will result in it becoming embedded across government in a substantive, enduring and effective manner. The Review was announced by the Prime Minister in November 2016 and has been undertaken as a part of the Industrial Strategy programme. The findings and recommendations in this report draw on:

- An examination of the history of the deployment of SBRI as a policy instrument (Chapter 3);
- Detailed analysis of quantitative data on competitions and awards collected by Innovate UK and a survey of participating companies carried out by the Manchester Institute of Innovation Research on behalf of Innovate UK in 2014/15;
- Spending department perspectives based on meetings with a range of SBRI programme managers, and with directors and other senior budget holders in some of the larger departments;
- Feedback from companies, obtained through a web-based consultation and two workshops in London and Manchester;
- Lessons from the US SBIR programme applicable to the UK context (Chapter 2);
- Examination of the relationship between SBRI and other relevant government innovation and procurement policies (Chapter 4);
- Lessons from the start-up models adopted by successful UK STEM based companies and the role of lead customers in economic development (Chapter 5).

Key Findings

The key messages from my review are:

SBRI has a unique and valuable role to play in the innovation and procurement landscape

SBRI combines two sets of objectives. First, by fostering innovation to support economic growth, particularly amongst SMEs with the long term potential to compete in international markets; and second, to help spending departments increase their cost effectiveness and meet other policy objectives, including providing improved SME access to government's annual procurement spending of over £265bn per annum (around 14% of GDP).

SBRI contracts have two phases: Phase 1 – Feasibility, followed by a more substantial Phase 2 - Product Development, for the most promising projects. This enables funding to be progressively focused on the projects most likely to deliver the procurement and commercial outcomes sought. And it helps departments manage the risks associated with developing innovative solutions.

A well run, properly financed, national SBRI programme offers benefits to both public sector customers and the UK economy as a whole. The other main policies for funding

business R&D, grants and R&D tax credits, operate by subsidising R&D, on the basis that making it less expensive will lead to an increase in supply. And, because they fund only part of the cost of R&D, their impact on start-ups and SMEs without venture capital backing is very limited. In contrast, SBRI operates by increasing the **demand for R&D** that will deliver innovative solutions to defined market needs. And as a contract it provides 100% funding.

SBRI enables the government to replicate the important 'lead customer' role played by large corporations and the US government in getting new innovative companies off the ground. By doing so it also provides "market pull" to complement the more "technology push" element of some other policies.

Implementation of SBRI varies widely across departments, with some very well managed programmes and a tail of less successfully implemented ones.

The way in which SBRI has been funded and managed varies widely across Government and there is a lack of central, and sometimes departmental, ownership. It is effectively an 'orphan policy'.

There are some very well managed programmes like those at NHS England, and NC3Rs (National Centre for the Replacement, Refinement and Reduction of Animals in Research). These have experienced teams that have worked together over many years to carefully define the challenges that need addressing and run a portfolio of competitions every year. In both cases the contracts awarded have been large enough to have a transformational impact on some of the companies backed by taking them to key development and testing milestones, and helping them secure procurement and/or other commercial sales. (See, for example, the PolyPhotonix, ADI, Fuel 3D and Actual Analytics case studies on pages 97, and 115 in the Appendix).

The longest running SBRI programme is NHS England's. It runs regular competitions twice a year and operates a systematic process from problem definition through to procurement support, with clinicians, commissioners and people with a business or venture capital background involved in selection interviews. Started in 2009 in the East of England, by February 2017 it had funded 67 projects through to Phase 2, over a quarter of which had led to commercial product sales to the NHS. A recent report undertaken by PA for NHS England shows growing deployment of SBRI funded technologies with the cumulative present value of benefits to the NHS from the £73m of NHS England SBRI funding since April 2014 forecast to rise to between £349m and £482m by 2022 and to between £1.2 billion and £1.9 billion by 2027.

The NHS SBRI approach represents the single best role model for future programmes from other public sector organisations, though there are important lessons from other SBRI programmes.

At the other extreme is a tail of much less well funded competitions, with a few projects that have led to commercialisation, but contract values that are often too low to make a real difference to a company's ability to take a project forward. About a half of departmental SBRI programmes have average contract values below the minimum guideline for individual projects. This includes the MOD which, for policy reasons, has opted to focus its limited innovation budget on small scale, early stage contracts. Less than 14% of its SBRI projects have moved beyond the Phase 1 feasibility stage, and average contract values for Phase 2 have been below the minimum SBRI guideline of £250k. This is significantly lower than the US equivalent, and in the case of most technologies, is unlikely to lead to either procurement or wider commercialisation.¹

Altogether, the experience of SBRI over the last 7 years indicates that a different approach to funding and managing it is needed if the full potential benefits are to be derived – by the public sector, by businesses and by the economy at large.

Budget restrictions or pressures are reported by all departments and agencies

SBRI budgets are currently entirely the responsibility of spending departments and agencies, and in some cases set on an annual basis. This is in stark contrast to the US SBIR programme where they are defined by law. This is a key feature of the US programme and underpins its continuity and effectiveness.

Despite the encouragement of Downing Street and the Cabinet Office, and the strong practical support provided by Innovate UK, total annual SBRI funding has failed to reach the Treasury's £100m 2014 target, let alone the £200m 2015 target. Indeed, SBRI spending has moved into decline as this top-level pressure has lessened. In 2015/16 it was 25% below its peak the previous year. The NHS SBRI budget has been cut by nearly forty per cent from its peak, and several successful SBRI programmes seem unlikely to be continued without action to change the funding model.

SBRI is highly valued by businesses that have used the programme

Around 62 per cent of SBRI funding goes to SMEs and econometric evidence suggests that, even at this relatively early stage, SBRI contracts have a positive impact on company

¹ There has been some increase in Phase 2 MOD funding in recent years and a new MOD Innovation Strategy was launched in December 2016. However, this is unlikely to have a material impact on the way the MOD operates SBRI.

revenues.² The case studies included in this report provide a more detailed picture. SBRI contracts have:

- triggered the creation of successful new firms;
- enabled more established SMEs develop and launch new products;
- provided credibility for companies to move into new applications and geographic markets as a result of UK public sector procurements;
- led to significant amounts of equity investment being raised in some of the companies funded;
- helped companies with a technology consulting model develop and market their own products;
- acted as a catalyst for struggling companies with novel technologies find applications and bring them to market.³

Products backed and already on the market range from a non-invasive therapy for diabetes related blindness to autonomous, long endurance, ocean research vessels, to military clothing with built in networking technology.

Businesses reported a number of positive impacts from SBRI, including providing an accelerated route to market, business growth and an increase in sales turnover. It has also built credibility and generated a “buzz” in their markets.⁴

Key advantages seen over other programmes included:

- 100% funding, frequently mentioned as a key benefit, both by micro and small businesses (i.e. those employing less than 50 people) and by larger businesses for which it made riskier R&D projects more feasible;

² Analysis of SBRI by the Manchester Institute of Innovation Research suggested that in 2014, two years after the award of the SBRI contract, Phase 1 winners estimated their sales were higher on average by £32,300, and Phase 2 winners higher by £224,300. Its econometric analysis – matching winners with similar firms in the non-applicant population – suggested a turnover increase of around 12.7 per cent on average across the Phase 1 and Phase 2 competitions. *A Review of the Small Business Research Initiative*, Manchester Institute of Innovation Research with the Enterprise Research Centre and OMB Research Ltd, 2017.

³ The impact of SBRI contracts on individual businesses is illustrated in the full report’s case studies and other company examples. The BEIS Annex 3 published with this report includes a further three case studies.

⁴ The BEIS Accompanying Document Part 2 summarises comments made at the Review workshops by SBRI recipients.

- Retention of IP, also regarded as a critical advantage compared with development contracts from private sector customers, allowing companies to sell applications to other customers;
- The market-pull implicit in SBRI and the fact that there was potential for a first (product) customer.

A number of those consulted regarded it as the most appropriate government innovation programme for their kind of business.

There are barriers to commercial procurement that need to be addressed

The main weakness in SBRI highlighted in company feedback was the weak pull through to public sector procurement; the final operational testing and adoption stages of the SBRI process remain problematic across many departments. This partly reflects the lack of phase 2 product development contracts, and low levels of funding in many SBRI programmes. The point at which commercial sales can take place is also affected by the long lead times involved in developing and testing many technologies, particularly where there are regulatory hurdles or long design-in times. However, weak procurement pull through is also the result of institutional and cultural factors.

In the case of the NHS, which has purchased more SBRI funded products than any other programme, the problem is aggravated by a complex, impenetrable and geographically dispersed approvals and commissioning process, so sales have tended to be small and localised. Though recent data suggest that the speed of adoption is increasing.⁵ The NHS England SBRI model needs to be enhanced to ensure that successful projects lead on as quickly as possible to products sales. Many recipients of SBRI contracts from the UK health sector have called for a 'Phase 3' to help address this problem, though it is also needed for SBRI programmes involving other parts of the public sector.

A more systematic, embedded SBRI programme management process is needed to achieve better procurement outcomes

Over the last decade or more, a number of approaches have been tried to encourage the procurement of innovative solutions by the public sector. These approaches have mainly been in the form of specific procurement tools for spending departments to use when officials thought them appropriate. However, only SBRI has so far achieved traction. The

⁵ This problem is recognised generally within the NHS and the Office for Life Sciences' Accelerated Access Review, published in November 2016, made recommendations to address it. The Government announced a series of measures as a "first step" in taking it forward in July 2017.

new, and still largely untested, EU *Innovation Partnership* rules could be attractive in some situations and help ease the transition from product development and evaluation through to commercial procurement, especially if applied as part of the SBRI process.

However, having a set of tools is only of value if you have a plan to use them. To transform the public sector's ability to use external innovations to drive improvements in cost effectiveness, it needs to learn from the private sector by embedding a systematic "open innovation" process in operations and future planning, including for major infrastructure projects.

SBRI programmes need to be conducted on a long term, systematic basis, and run by stable teams with innovation programme management expertise. Challenge selection is a key part of this. And multifunctional teams, including users, decision makers and budget holders, must be involved throughout the process, from problem definition to product testing and first deployments.

SBRI has the potential to help grow significant STEM based companies over the long term

R&D contracts and lead customer development funding – from both the private and public sectors - have played a key role in the early stages of many of the most successful UK science and technology based companies to have been started over the last forty years. For some, venture capital was simply not available. For others, customer funding has enabled them to delay, minimise, and sometimes avoid, significant external investment, thereby retaining control by the founding team. The histories of ARM Holdings (a spin out from Acorn Computers), Autonomy (a spin out from Cambridge Neurodynamics) and Vodafone (a spin out from Racal) can all be traced back to a "first break", in the form of a public sector innovation contract that their parent companies received as start-ups.⁶

By playing this lead customer role in a systematic manner, SBRI could:

- help companies develop to the point where they are "VC ready";
- help entrepreneurs who want to build a substantial UK business over the long term retain managerial independence and avoid pressures for early trade sales.

⁶ These broader economic arguments for SBRI and other lead customer based innovation policies are discussed in Chapter 5. The histories of successful STEM based UK companies are available at <http://www.davidconnell.org> .

It could also play a part in commercialising research breakthroughs through the process of undertaking sequential, specialised application contracts for different customers which often takes place before significant markets open up.

Limitations on SBRI data prevent effective programme monitoring and promotion

Monitoring SBRI and measuring its impact is complicated by the wide variations in funding and approach across departments, and by the lengthy development, testing, approvals, and purchasing cycles entailed for many products. It is further complicated by the fact that spending departments have no obligation to share data with Innovate UK. This situation contrasts strongly with the US SBIR programme, where agencies are required to operate transparently and publish information on award winners, project objectives, and contract amounts. This is available on a free, searchable, public database.

Recommendations

Recommendation 1: A New Central SBRI Fund

A central fund should be established with a rolling 5-year budget profile into which teams from public sector organisations can bid to fund a programme of SBRI competitions.

- The central SBRI programme budget should be set for five years into the future, and renewed annually, permitting funding of SBRI competitions on a planned basis from problem definition to completion of the final phase of funding;
- Government should plan for the annual value of SBRI contracts awarded by spending departments to grow to around £250m per annum over six years. Assuming well established SBRI programmes continue to be funded directly by departments at roughly current rates, this equates to central fund expenditure growing to £120m by 2020/21 and £200m by 2023/24;
- Initial allocations to a limited number of well managed programmes with budgetary or funding model restrictions could begin in 2017/8, providing strong proposals are put forward;
- Central funding should include a small element for department or agency programme management costs where appropriate.

I propose that the central fund is named the *Tommy Flowers Fund*, after the British creator of Colossus, the world's first programmable electronic computer to help read German army messages encrypted using the Lorenz cipher in the latter stages of the second world war.

Recommendation 2: A National SBRI Fund Board

The fund should be overseen by a small National SBRI Board reporting to the Cabinet Office and comprising officials bringing commercial, innovation and operational perspectives from the public sector, including Innovate UK, together with individuals from the private sector with business and venture finance expertise.

Its responsibilities should include:

- Setting funding conditions and guidelines for four year funded departmental and agency SBRI programmes to ensure conformity with objectives and best practice,
- Reviewing and approving departmental or agency programme proposals, including the approach and expertise proposed for programme management;
- Monitoring SBRI programme progress and performance;
- Publishing an annual report;
- Delivering cross-programme support measures like conferences, training, etc;
- An annual awards ceremony similar to that run by the US SBIR that recognises the achievements of programme management teams and SBIR beneficiaries.

Recommendation 3: Phase 1 and Phase 2 Funding Guidelines

SBRI contracts financed through the central fund must be sufficient to take projects to a meaningful milestone. The amounts required will depend on the task. But in general programme guidelines for Phase 1 and Phase 2 contracts (£50-£100k, and £250k-£1m respectively) should be closely adhered to.

- Most Phase 2s should be expected to be at the top end of the range;
- The percentage of projects graduating from Phase 1 to Phase 2 should be broadly in line with the US SBIR norm of 40 to 50%, providing they are of sufficient quality;

- Phased payments, including an upfront element should be adopted to make the programme as SME friendly as possible.

Recommendation 4: Selective New Phase 3 Contracts for Evaluations and Trial Deployments

SBRI programme bids should include an element for Phase 3 funding where appropriate. However, contracts should be awarded very selectively, and only when the viability of the technology has already been well demonstrated and there is strong interest in an operational scale evaluation by prospective customers.

- The form of Phase 3 project funding should not be limited to 100% contracts. Programme managers should be able to consider other elements in the funding package, including mechanisms to provide a potential return on the government investment. One possible mechanism is through equity investment options. This is a model similar to that used by In-Q-Tel, the CIA's very successful security technology fund;
- Phase 3 contracts should only be awarded to companies that have demonstrated that with this, and other sources of finance, they are likely to be able to take the project forward to commercialisation. The two year Phase 2 funding provides a runway for companies to raise money or find partners if needed;
- Where appropriate Phase 3 contracts should include an element for specialised business consultancy support.

Recommendation 5 Embedding Best Practice Innovation Programme Management within Departments

The National SBRI Board should ensure that the SBRI programmes it funds are fully embedded within departments and operated in a systematic manner using best practice, innovation programme management processes. They must be directed, managed and supported in a way that maximises the probability of commercial procurement and commercialisation of successful developments.

Key aspects should include:

- Small Programme Boards established for each major programme, drawing on business and/or VC experience to steer, oversee and support management teams.

This should include supply chain experience where products are not bought directly by the public sector;

- SBRI programme management teams that include people with both technology programme management expertise and knowledge of the department or agency's operations. It will often be necessary to recruit from outside government;
- A systematic approach to challenge selection and definition, covering different aspects of a sponsoring agency's responsibilities through a rolling programme of competition topics;
- SBRI competition management approaches involving challenge owners, potential users, budget holders and other key decision makers, including, where appropriate, prime contractors, throughout the SBRI process, from problem definition to evaluation and operational trials;
- Face to face interviews with shortlisted applicants by panels including participants with technical, procurement and business or VC perspectives.

Recommendation 6 Transparency, Monitoring and Evaluations

All SBRI programmes receiving central funding should be required to provide details of awards, including recipients, contract amounts and summary project descriptions through a publicly searchable database similar to SBIR's TECH-Net. Future monitoring information obligations should be included in SBRI contracts with companies

Ongoing monitoring should be complemented by more comprehensive reports at five yearly intervals, starting in 2022. Evaluations should focus on real, leading event-based indicators of progress, as well as quantitative measures.

Branding

The Small Business Research Initiative is now an established brand. Though, under EU regulations, it is not exclusively reserved for small businesses, and it is about product development and trialling, not research. Whether it should be rebranded, and if so how, should be considered prior to launching the central fund.

Chapter 1 – Introduction

The Government's Industrial Strategy Green Paper⁷ signalled the most significant commitment to policies to strengthen the UK's industrial base and develop its regional economies for at least 40 years. It seeks to create a portfolio of measures to increase the competitiveness of existing industrial sectors where the UK is already strong, and to sustain and increase the UK's attractiveness for inward investors bringing high value job opportunities. A key objective is to make the UK one of the most competitive places to start or grow a business, not by 'backing winners', but by creating the right conditions for new and growing businesses to thrive.

Innovation and procurement are key planks in this strategy. Innovation drives productivity and competitiveness in existing businesses and it enables the creation of new ones to replace those in decline. The UK's under exploited strengths in academic science, technology, engineering and mathematics (STEM), makes the development of more effective innovation policies to capitalise on these strengths a clear priority. Innovation also helps improve the cost-effectiveness of public services.

Government procurement represents a similar national asset which could be better used to drive economic growth. The public sector spends around £265 billion a year through procurement, equivalent to 14% of GDP⁸. This covers a very wide range of products and services. Helping UK companies, especially SMEs, take advantage of this market opportunity better could provide them with a springboard to grow sales at home and abroad.

The Small Business Research Initiative (SBRI) combines both of these elements. It works by awarding contracts to new ventures and SMEs to develop innovative products that address unmet public sector needs, either as a customer, or to help achieve its policy goals. It offers a win-win opportunity for both the public sector and UK businesses alike. And it provides a way of harnessing the power of government procurement to build a stronger UK economy capable of paying for the public services we deserve.

⁷ *Building our Industrial Strategy* (January 2017) available at https://beisgovuk.citizenspace.com/strategy/industrial-strategy/supporting_documents/buildingourindustrialstrategygreenpaper.pdf .

⁸ Includes Government Gross Current Procurement and Gross Capital Procurement from HM Treasury's *Public Expenditure Statistical Analyses*, chapter 5 basis, available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/594905/PSS_February_2017.pdf.

Based on the highly regarded US Small Business Innovation Research (SBIR) programme, the UK SBRI was first trialled in its current form in 2008/9, after a long campaign backed by leading entrepreneurs, venture capitalists and university researchers. Since then, annual expenditure has grown to a peak of around £81M in 2014/15, helped by strong support from both the Treasury and Cabinet Office. Success has been demonstrated across different technologies and government departments.

Nevertheless, many parts of the public sector have failed to engage in a meaningful way and spending levels show no sign of reaching the target of £200M a year set by George Osborne in 2013, a figure broadly in line with the US SBIR given the relative sizes of the two economies. Indeed, SBRI spending in 2015/16 was 24 per cent lower than the previous year.

My aim in this report is to examine what SBRI has achieved to date and how, and to make recommendations that will result in it becoming embedded across government in a substantive, enduring and effective manner. The Review was announced by the Prime Minister in November 2016 and is undertaken as a part of the Industrial Strategy programme.

The full terms of reference are shown at Appendix 2.

Approach

The review draws on six sources of information:

- The history of the deployment of SBRI as a policy instrument in the UK;
- Data on competitions and awards collected by Innovate UK, and a survey of participating companies carried out by the Manchester Institute of Innovation Research evaluation of the SBRI programme on behalf of Innovate UK in 2014;
- Departmental perspectives, based on meetings with a range of SBRI programme managers and with directors and other senior budget holders in some of the larger departments;
- Feedback from companies, obtained through a web-based consultation, two workshops in London and Manchester and the results of the earlier Manchester study;
- Lessons from the US SBIR programme;
- Lessons from the early history of some of the UK's most successful STEM based companies.

I am grateful to all who have given their time to participate in the process.

Report Structure

Before examining SBRI, **Chapter 2** of this report first describes the US SBIR programme which inspired it. It highlights the key features of the programme. And it draws out key lessons from independent reviews of the US programme that could help improve SBRI and tailor it to the different circumstances of the UK, with its much lower overall levels of public sector R&D spending.

Chapter 3 looks at the UK SBRI programme and highlights the wide variations in how the programme has been implemented across government: in some cases through long running, well managed programmes; in others with less top level enthusiasm or with funding models that are out of kilter with SBRI's philosophy and objectives. For all government SBRI programmes to work as well as the best, they need to be implemented in a way that brings them closer to the US SBIR funding model.

To have value as a government policy, SBRI must deliver something different to and/or better than other related policies. **Chapter 4** examines how SBRI is differentiated from other, longer established innovation policies, focussing particularly on those designed to support R&D spending by start-ups and SMEs. It also examines other procurement mechanisms that have been introduced to make the public sector more open to innovation from outside, and it discusses how best practice innovation management approaches from the private sector could be adapted through SBRI to embed innovation within commercial departments.

Chapter 5 examines the contribution that SBRI could make to the Industrial Strategy over the long term. Customer funded R&D contracts and lead customers have played a key role in the early stages of many of the UK's largest STEM based UK companies. By helping to reduce, delay or avoid the need for institutional finance at this early stage, SBRI contracts with public sector customers can also help entrepreneurs avoid early trade sales and retain the independence needed to build substantial, world class UK businesses.

Finally, **Chapter 6** draws together the key conclusions from these different sources and makes recommendations for redesigning the SBRI programme so that it can deliver the benefits sought by government and businesses alike.

Appendix 1 summarises SBRI programmes operated by a selection of departments and agencies.

CASE STUDY 1: Photobit: How SBIR and Other Lead Customer Funded Development Contracts Helped Create Our Camera Phones

Photobit Technology Corporation was founded by Dr Eric Fossum, Dr Sabrina Kemeny, and associates from NASA's Jet Propulsion Laboratory in 1995 to commercialise the CMOS image sensor technology they had invented there.

Photobit's early development was funded, in part, through government R&D contracts. These included an SBIR contract from the US Army to develop high-resolution, high speed image sensors for recording test missile launches, and other SBIR awards from DARPA, NASA, the US Navy and the Ballistic Missile Defence Organisation.

As the power of the technology increased it became increasingly used in a range of commercial applications. Photobit's non-defence contracts included industrial machine vision, high-speed scientific imaging, a pill-camera for medical imaging, and animation systems for motion pictures, television and video games. Cameras using its technology were used in several Hollywood films, including Star Wars Episode II.

By 2000 Photobit had annual revenues of \$20M, and further improvements in performance and reductions in manufacturing costs had begun to open up opportunities for volume applications in digital cameras and mobile phones. As a result, the company was able to attract a \$26M venture capital investment from Intel, Hitachi and Basler A.G. The following year, Micron Technology Inc. a major specialist US semiconductor company, acquired Photobit to enable it to enter this fast growing market.

In February 2017 Eric Fossum was awarded the Queen Elizabeth Prize for Engineering at the Royal Academy of Engineering in London.

"I am a strong advocate of the US SBIR programme as I think there need to be channels other than traditional venture capital to seed new technology businesses. SBIR awards help companies that wouldn't otherwise attract venture capital funding because they have a slow growth profile, or a niche market appeal.

"They help entrepreneurs because they allow more 'self-start' and less dilution for the founders of such companies. But they are also very helpful to the government on many levels, seeding businesses that are developing technologies useful to government agencies – and, often, to us all."

Professor Eric Fossum

Chapter 2 - Procurement Based Innovation in the US and the Small Business Innovation Research Programme

Chapter Summary

- SBIR has been the primary US Federal Government Policy to support innovation in small businesses for 35 years. It is described by the SBA as “America’s Seed Fund”
- Its phased approach to funding businesses to develop solutions to defined public sector needs is very different to the UK’s grant based policies. SBIR can provide both customer pull and sufficient funding to have a transformative effect on a business.
- SBIR provides an SME friendly route into mainstream R&D and procurement budgets in the Department of Defence and other agencies
- The UK can learn from measures introduced in the last ten years to enhance SBIR procurement and commercialisation rates

Introduction

The role of US Federal Government R&D and procurement funding in stimulating the development of new high technology sectors in the United States is well known, with the Department of Defense (DoD), including DARPA, and NASA playing a key role.⁹ The main funding organisations are the DoD (\$71 billion), NASA (\$10 billion) and the National Institutes of Health (\$31 billion).

⁹ See, for example, *The Biggest “Angel” of Them All: the Military and the Making of Silicon Valley*, Stuart W. Leslie in *Understanding Silicon Valley*, ed. Martin Kenney, Stanford University Press, 2000.

US Federal Government spending on R&D represents a much higher proportion of GDP than in the UK – 0.9% as opposed to 0.6%. It is dominated by the DoD, responsible for 54% of the total, compared with 16% for the Ministry of Defence in the UK.

Furthermore, the DoD plays a very different role in the US national innovation system to that of the MOD. This includes being a major funder of university research in the physical sciences. While the non-medical sciences UK Research Councils are responsible for 24% of total UK Government R&D funding, the National Sciences Foundation, the nearest US equivalent, represented just 4% of total US Federal R&D funding in 2014.

The DoD and other agencies like NASA and the Department of Energy also operate a string of their own large applied research labs, like the DoD Lincoln Laboratory, closely linked to MIT and the Department of Energy's Lawrence Berkeley Lab linked with the University of California. And they place R&D contracts with a number of large not-for-profit R&D organisations like SRI International in Stanford, which developed the speech recognition technology that became *Siri*, the Apple iPhone's intelligent personal assistant.

In drawing on the US experience to examine the role SBRI could play in the UK, and how it might be configured, it is important to take account of this broader picture.

History and Objectives of the Small Business Innovation Research Programme

The Small Business Innovation Research (SBIR) programme was established under the Small Business Innovation Development Act in 1982 and expanded in scope through subsequent legislation in 1988 and 1992.¹⁰ Initially there was strong opposition from universities and federal agencies concerned with losing control of a proportion of their budgets. But campaigners argued that small businesses were a major jobs generator and there was increasing awareness of the role small firms play in innovation. According to the SBA, amongst high patenting firms, small businesses produce 16 times more patents per employee than large companies.¹¹

The objectives of SBIR are to:

- stimulate technological innovation;
- use small businesses to meet Federal R&D needs;

¹⁰ In December 2016 SBIR and the closely related STTR were extended until 2022.

¹¹ Frequently Asked Questions, SBA Office of Advocacy 2014. High patenting firms are defined to be those with 15 or more patents in a four-year period.

- foster and encourage participation by socially and economically disadvantaged small businesses (SDBs), and by women-owned small businesses, in technological innovation;
- increase private sector commercialisation of innovations derived from Federal R&D funding.

The SBIR legislation requires that all federal agencies with R&D expenditures over \$100m spend a defined proportion of their external R&D budgets with small businesses through the SBIR process. This proportion was increased in the 2011 SBIR Reauthorisation Act in steps from 2.5% in FY 2011 to 3.2 % in FY 2017. Within this there are smaller targets for participation by women and minority owned businesses.

Company Eligibility

Only “for profit” businesses are eligible for SBIR awards and the R&D must be undertaken in the US. Until 2011 businesses had to be majority owned by US citizens, but after lobbying by venture capital firms and others, the 2011 Reauthorisation Act allowed 15% of agency SBIR funds to be awarded to businesses more than 50% controlled by venture capital firms. The allocation limit is 25% for the National Science Foundation, Department of Energy and National Institutes of Health.

SBIR is aimed at small businesses, defined in the US to be those employing less than 500 people, though most award winners are much smaller. In the case of the Department of Defense, which runs the largest SBIR programme, over 70% of Phase II contracts go to firms employing less than fifty people.¹²

SBIR is aimed at businesses, rather than academics, but up to a third of the Phase I work and a half of Phase II may be subcontracted to another firm or not-for-profit research institution. The “*principal investigator’s*” primary employment must be with the small business undertaking the project at the time it is started.

The closely associated, but smaller, Small Business Technology Transfer (STTR) programme requires the business to undertake at least 40 per cent of the work and a research institution at least 30 per cent. In other respects STTR operates just like SBIR.¹³ Competitions are run separately, though often in parallel with SBIR competitions. In 2016

¹² *SBIR at the Department of Defense*, Committee on Capitalizing on Science, Technology and Innovation Assessment, National Research Council. National Academies, 2014

¹³ STTR supports cooperative R&D between small businesses and US universities and research institutions with the aim of technology transfer and commercialisation.

an additional 0.45% of federal agency external R&D budgets was set aside for STTR. Five agencies participate.

How SBIR Operates

The way in which the SBIR programme is structured and managed is an important reason for its success. Key elements are as follows:

- Agencies advertise topics (“solicitations”) in groups, typically twice a year; each topic relates to an agency’s requirements for new technology, either for its own use or to meet its broader objectives
- Awards are made on a competitive basis in two phases:
 - (a) Phase I, up to \$150,000 for a feasibility study, over 6 months
 - (b) Phase II, up to \$1million, over up to 2 years, typically for development of a demonstrator, and awarded to roughly 50% of Phase I winners.
- SBIR projects that subsequently receive follow on government funding from non-SBIR budgets are defined as entering “Phase III”.¹⁴ Phase III federal funding can be awarded on a non-competitive basis, and the Act directs agencies and prime contractors to award any contracts using the results of Phase 2 projects to the originating companies “to the greatest extent practicable”, whether these are for further R&D or procurement of products or technologies. If a company is sold this near monopoly right is acquired by the purchaser
- SBIR awards cover 100% of firms’ project costs plus a profit element. This is especially important for smaller firms, and contrasts with UK and EU grants programmes where significant company contributions are required.
- There is no requirement for collaboration with any other organisation, again unlike most EU and UK grant programmes.
- The company owns any IP generated.

¹⁴ The Small Business Administration describes Phase III as the period during which Phase II innovation moves from the laboratory into the marketplace. To commercialize their products, small businesses are expected to find funding from the private sector or agency that made the initial award. It recognises that “this can pose significant challenges for new technologies and products developed under SBIR awards.”

CASE STUDY 2: iRobot: From Bomb Disposal to Floor Cleaning

iRobot Corporation was founded in 1990 by Colin Angle and Helen Greiner who had studied together at MIT's Artificial Intelligence Laboratory, before working for a year or two in industry, and Rodney Brooks, the MIT Laboratory's Director. Initially based in Angle's apartment, funding came from personal credit cards and \$100,000 in bank loans.

The company's first big government contract, to develop an automated underwater minesweeper for the Office of Naval Research, came in 1993. This enabled it to scale up its operations. The bulk of its business was focused on developing products for the military though it also undertook contracts for industry.



The key breakthrough was in 1998 when iRobot won a DARPA contract to develop the PackBot, a mobile robot for reconnaissance, surveillance and bomb disposal tasks. PackBot was used at the site of the World Trade Centre in the aftermath of 9/11 and was deployed with US troops in the field from 2002.

The same year iRobot raised \$1.5m of external capital, its first external fund raising since the business was formed. This was followed by a further \$32m in five rounds of investment and an IPO in 2005. But the soft start-up model¹⁵ ensured that founders, directors and management still owned two-thirds of the company's shares.

Government R&D contracts continued to finance a lot of platform R&D. Between 2001 and 2009 the company won at least nineteen separate SBIR awards from the DOD, totalling \$8.6m, and as it grew in size, larger (i.e. non SBIR) R&D contracts became more important. Between 2007 and 2009 it received \$65M in Government R&D contracts. Only 40 per cent of its total R&D spending was funded from other revenues.

¹⁵ The term "soft start-up" was first coined by Matthew Bullock, banker to some of Cambridge's best known technology companies in the early 1980s. It describes an R&D services business model compared with the "hard start-up" model in which investment is raised by founders to develop and market a well defined product idea. Many successful product companies begin their lives as soft start-ups. See also Exploding the Myths of UK Innovation Policy, David Connell and Jocelyn Probert, Centre for Business Research, Cambridge Judge Business School, 2010

Alongside its defence contracts, iRobot began to develop consumer and industrial robots that could be sold in higher volumes. Its first floor-cleaning robot, Roomba, was launched in 2002, and within two years it was deriving 75 per cent of its \$95m annual revenues from consumer products.

iRobot fully acknowledged the benefits to its broader business of its Government R&D contracts in its annual reports to shareholders.

“We leverage our research and development across all of our products and markets. For example, we use technological expertise developed through government-funded research and development projects across our other product development efforts... This strategy helps us in avoiding the need to start each robot project from scratch, developing robots in a cost-effective manner and minimizing time to market..... We retain ownership of patents and know-how and are generally free to develop other commercial products, including consumer and industrial products, utilizing the technologies developed during these projects”



By 2014 iRobot employed 528 people and consumer products were responsible for 88 per cent of its \$487m revenues. It had also become a much more global business, with exports accounting for some 60 per cent of sales. R&D expenditures remained high at \$64m, with 15 per cent of this expenditure covered by development contracts, mainly for the Federal Government. In 2016, it sold its defence operations to concentrate on its fast-growing business of products for the home.

The Small Business Administration describes SBIR as America's Seed Fund. The SBA's role is to promote, monitor and report on SBIR. It is also responsible for providing a website - sbir.gov - as a central information point for applicants and for maintaining a comprehensive, publicly searchable database of all awards.¹⁶ All other aspects of managing SBIR programmes are the responsibility of the funding agency.

Each agency operates SBIR in a slightly different way, and the National Institutes of Health, National Science Foundation and Department of Energy, for whom SBIR is aimed more at policy challenges rather than their own procurement needs, designate awards predominantly as *grants*, rather than *contracts*. This reflects greater openness to company ideas and a rather different usage of the word "grant" to that in the UK. Under EU State Aid Regulations, R&D "*grants*" cannot fund 100% of project costs.

There are regular national and regional SBIR conference across the US and specialist private sector organisations that provide data, commentary and advice on the programme.

Many states offer small grants to help firms prepare SBIR applications. Some provide additional grant funding to SBIR awardees.¹⁷

The US SBIR programme has been independently endorsed by Congressional committees and independent reviewers at intervals throughout its 35 year history and is highly regarded by government agencies, entrepreneurs, venture capital firms and policy makers.

It is very well documented and the National Academies of Science, Engineering and Medicine has published a series of detailed reviews of SBIR and STTR programmes run by different agencies.

Federal Agency Participation

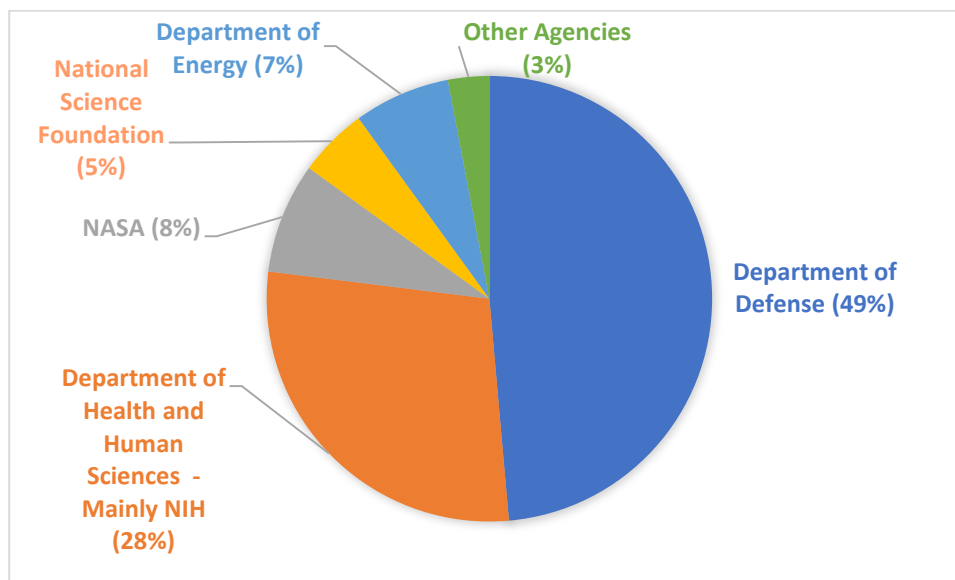
Eleven agencies operate SBIR programmes. The Department of Defense and National Institutes of Health, Part of the Department of Health and Human Sciences, are the largest.

Today, Phases I and II of the SBIR and STTR programmes are worth around \$2.5 billion per annum. Phase III funding is not documented, but it can be considerable in some agencies. US Navy data indicates that Phase III is worth three and a half times as much as its spending on Phases 1 and 2 combined.

¹⁶ tech-net.sba.gov. The SBA database is not always up to date. More comprehensive databases are available from commercial sources.

¹⁷ *Secrets of the World's Largest Seed Capital Fund*, David Connell, Centre for Business Research, University of Cambridge, 2006.

EXHIBIT 1: BREAKDOWN OF SBIR/STTR FUNDING BY AGENCY 2011



Source: US Small Business Agency; see <https://www.sbir.gov>

Award Sizes and Applicant Success Rates

In 2011, the latest year for which full data is available, the average size of Phase I awards was \$141k and the average for Phase II was \$964k. Application success rates were 15% for Phase I applicants and 49% for Phase II.¹⁸

Although SBIR awards are generally not supposed to be worth more than \$150k for Phase I and \$1million for Phase II, the law allows agencies to exceed this by as much as 50%, and by more than 50% for specific topics with SBA approval. It also allows agencies to make two further sequential Phase II awards to continue the work of an initial Phase II award, with similar flexibility in terms of award size. This means that up to \$3m in Phase II awards can be made for a single project at an agency's sole discretion.

Multi-million dollar projects are fairly common amongst the larger SBIR programmes. Between 2002 and 2011, 10% of DoD Phase II awards exceeded \$2m. Phase III provides for additional funding on an ad hoc basis out of other DoD budgets.¹⁹

¹⁸ *Small Business Innovation Research and Small Business Technology Transfer Programmes*, US Congressional Research Service, August 2014.

¹⁹ *SBIR at the Department of Defense*, National Research Council, The National Academies Press, Washington DC, 2014.

The NIH also has a history of making large awards. In 2014, 19% of Phase II awards exceeded \$1.5m and nearly a third of these exceeded \$3.25m. ²⁰

As we will see in Chapter 3, many UK departments award SBRI contracts that are much smaller than the US average and this limits what they can achieve.

CASE STUDY 3: Illumina

Formed in 1998 in San Diego by two partners in a venture capital firm, Illumina was set up to exploit technology licensed from Tufts University. It raised \$8.6m in venture capital the same year and this was followed by a further \$28m in 1999 and \$100m on IPO in 2000.

Despite these cash reserves it applied for and won \$10.3m in SBIR awards from NIH between 2000 and 2008. According to Dr Mark Chee, its first research director, SBIR provided cash for projects that would not have been funded in the normal course of company business and these projects turned out to be of critical importance to the development of the core product line. Advanced Liquid Logic, which Illumina acquired in 2013, was set up on the back of two small SBIR awards in 2004 to exploit technology developed by one of its founders, a DARPA funded PhD student at Duke University. ALL went on to win \$17m in SBIR awards and raise \$5.3m in venture capital before its acquisition.

Today Illumina employs around 5500 people worldwide and has revenues of \$2.2 billion. But its main business is in gene sequencing technology, built largely on its acquisition of Solexa, a UK VC backed company set up in 1998 to take forward a new approach to sequencing invented by two academics from Cambridge University's Chemistry Department. Solexa launched its first sequencer in 2006 and was acquired in 2007.

In Jan 2017 Illumina was one of two businesses inducted into the SBIR hall of fame at a ceremony in the White House.

²⁰ SBIR/STTR at the *National Institutes of Health*. National Academy of Science, Engineering and Medicine, National Academies Press, Washington DC, 2015.

Frequent Award Winners

Multiple SBIR award winners are quite common. Between 2002 and 2011, the top 20 DoD SBIR award winners accounted for 14% of all DoD Phase I awards. Ten companies were awarded between 10 and 22 Phase II contracts a year. There are multiple winners of NIH awards as well, though the phenomenon is much less pronounced. Between 2005 and 2014, 18 businesses won ten or more NIH Phase II's.

These frequent award winners are sometimes known as SBIR “shops” or SBIR “mills”. The phenomenon is the subject of much debate, especially concerning the relatively low rates of commercialisation by some of these firms.²¹ In the case of the DoD their existence partly reflects the DoD's huge appetite for “research” and a desire to explore future technology options. Commercialisation rates reflect the challenging nature of some of the work it commissions. But it is also likely that finely honed proposal writing skills have played their part.

When challenged about this phenomenon, the DoD has argued that these multiple award winners deliver what the DoD needs.

Specialised firms often use SBIR projects as an entry point to mainstream DoD R&D contracts and the supply of specialised products. One of the most frequent SBIR contract winners, Foster Miller, was acquired by QinetiQ in 2004 and has a strong focus on developing and supplying robots and other specialised niche technologies. Physical Optics Inc., the most frequent DoD SBIR contract winner in recent years received \$100m in DoD supply (i.e. non-R&D) contracts in 2016 alone. It has also spun off several product businesses. So, in some respects these companies have business models similar to the non-defence orientated Cambridge consultancies, with an R&D service model leading on to opportunities to license the resulting technology to larger defence companies or supply product in small volume, couple with occasional opportunities to create a significant product business and spin it out.²²

²¹ A study for the US Air Force found that commercialisation success was inversely related to the number of awards. See: <https://www.sbir.gov/sites/default/files/USAF%20SBIRSTTR%20Economic%20Impact%20Study%20FY2015.pdf>.

²² Since 1960, the Cambridge Technology Consultancy sub-cluster has grown to around 2000 employees and has created many successful spin-off product businesses employing several times this number. (See *Exploding the Myths of UK Innovation Policy*, David Connell and Jocelyn Probert, op.cit.)

In the case of NIH, it is clear that some companies have received multiple awards to support long-term biotechnology programmes, though good proposal writing skills probably also play a role here.

Whatever the reason for these multiple award winners, a UK SBRI programme, with a much more limited budget than the US SBIR, has to be much more focused on projects of real value to the public sector and companies determined to create profitable product businesses. A more challenging, quasi venture capital approach, such as that used by the NHS England SBRI, rather than the paper based administrative approach adopted by the US SBIR, can help achieve this. Chapter 6 discusses how embedding a more systematic approach could deliver better procurement outcomes and commercialisation rates in the UK.

Relationship of DoD SBIR with Other DoD Programmes

In the Department of Defense and some other agencies, the SBIR programme is just the first step on the procurement ladder for small science and technology-based firms. Larger R&D contracts are available from the remaining 96% of external departmental budgets not earmarked for SBIR or STTR. These are advertised through Broad Area Announcements (BAAs) and other mechanisms. There are significant opportunities for small businesses to participate, directly, or as a subcontractor to a larger firm.

Two specific non-SBIR DoD programmes should be noted.

The first is the Department of Defense Rapid Innovation Fund. This provides \$250m of funding per annum outside the SBIR and STTR budgets and is also aimed at small businesses. It is focused on taking technologies which have already been validated to the point where they can be tested in an operational environment. In this respect, it is similar to the MOD's Defence Equipment and Support SBRI, described in the Appendix. RIF competitions are highly competitive and award single Phase Contracts worth up to \$3m.

Examples include additive manufacturing technology to reduce aircraft maintenance and down time, and technology to increase the speed of electronic intelligence dissemination.

The second DoD programme of note is DARPA.

DARPA was originally set up in 1958 in response to the launch of Sputnik by the Soviet Union. Its mission today is *"to prevent strategic surprise from negatively impacting US national security and create strategic surprise for US adversaries by maintaining the technological superiority of the US military"*. DARPA has a \$3 billion a year budget and focuses on longer term defence related challenges, predominantly through a programme of phased, multi-year R&D contracts. It mainly uses a model involving a prime contractor and defined subcontractors, rather than the multi-partner collaborative model, historically

favoured for large innovation projects in the EC and UK. The scale of DAPRA projects is generally an order of magnitude larger than SBIR awards.

Many DARPA and other DoD R&D projects also have civil applications. The da Vinci Surgical System, sold by Intuitive Surgical, the global leader in robotic-assisted minimally invasive surgery, has its origins in a US Army funded project at SRI International. This was originally aimed at the more ambitious objective of remotely controlled surgery close to the battlefield.

Commercialisation

The rate at which SBIR funded technologies are commercialised has been a strong focus of US Government reviews of SBIR and it has called for various actions to improve them.²³ SBIR funded companies have argued that DoD procurement officers find it easier and more convenient to deal with established contractors.²⁴

Since about 2005, all agencies have taken measures to improve commercialisation rates. For example, a 2007 DoD report identified four actions required “to successfully transition technology from science and technology (S&T) funding into defense acquisition programs”:

- Expanding resources for maturing technology beyond Technology Readiness Level (TRL) 5;
- Expanding resources and developing strategies for mitigating risk in innovative technologies;
- Reducing barriers to competition and to new suppliers such as small business;
- A formal DoD-wide mechanism for improving technology transition from S&T into defence acquisition programs.

After some initial pilot programmes, these proposals have formed the basis of different approaches adopted by DoD branches.

²³ A survey in 2011 undertaken as part of the National Academies of Science study found that 15% of Department of Defense Phase II projects initiated between 1998 and 2007, most of which are in highly specialised areas, had resulted in more than \$1m sales or licence fees, 30% less than \$1million and a further 25% of projects were expected to deliver future revenues. The figures for NIH are comparable. A survey in 2014 of Phase II awards made between 2001 and 2010 found that 2% had resulted in sales of greater than \$20m, 12% sales of \$1m to \$20m, 23% less than \$1m and a further 26% expected sales in the future.

²⁴ *SBIR and the Phase III Challenge of Commercialization, Report of a Symposium* Editor: Charles W Wessner. National Academies Press, Washington 2007.

In the case of the Air Force, non-SBIR Air Force funds have been made available for a Commercial Readiness Programme (CRP) financed jointly with other partners and run sequentially with Air Force SBIR Phase II extension funding. This can increase funding for selected SBIR projects to up to \$3.15m, prior to the Phase 3 transition into commercial procurement. In the four years from FY 2007 to 2011, \$91m of Air Force CRP funding attracted a further \$152m from Air Force Acquisitions budgets and \$54m from industry. In the case of the US Navy, its \$271m of SBIR Phase I and Phase II awards in 2012 attracted a further \$650m in Phase III Navy funding. Funding from other branches of the DoD was probably worth around a further \$300m.²⁵

Other measures include the provision of business advice on commercialisation to firms by specialist consultancies and a range of measures by DoD to involve larger defence contractors. Companies like Boeing and Lockheed Martin have their own SBIR programmes. These aim to make their technology interests known to potential SME suppliers, offer letters of support to applicants whose proposals they find of interest, and provide practical help in areas like engineering and testing to support insertion into their own R&D and supply programmes.

The latest National Academies report on the DoD SBIR notes that: *“Given the long lead time and complexity of many DoD programs, increasing the take up of SBIR funded technologies through acquisition of the different components required considerable planning – and shifts in the way that planning was undertaken”*.

The actions taken to improve SBIR commercialisation (and procurement) rates have important lessons for the UK, and are reflected in my recommendations.

Ultimately, in a programme like SBIR, focusing on very early stage, often rather speculative, technology developments by start-ups and small companies, it is the small percentage of really successful projects that define success, together with the accumulated experience of participants who may move on to other new ventures.

The history of Qualcomm, inducted into the SBIR Hall of Fame in 2011, illustrates this process. Today, a global leader in telecommunications technology, it is in fact the founders' second company. The first, Linkabit, was set up in San Diego as a specialised consulting business in 1968 and lived off satellite communications consulting contracts for NASA and the DoD before gradually moving into supplying components, then entire devices to major defence electronics companies and later commercial customers. Linkabit was sold in 1979, but in 1985 two of its founders and five ex-employees started Qualcomm to repeat the journey, again starting with government contracts.

²⁵ *SBIR at the Department of Defense*, National Academies, 2014 op. cit.

Between 1987 and 1990 Qualcomm won eight Phase I SBIRs and four Phase IIs. Ex Linkabit employees founded another nine communications start-ups in San Diego and three elsewhere.²⁶ In 2016 Qualcomm had revenues of \$24 billion and 30,000 employees worldwide.

Lessons for UK SBIR

Key features of the US SBIR include:

- Its ring fenced funding and clearly defined approach and funding rules. This underpins the longevity and consistency with which it has been run, bringing clarity for programme managers and companies, and allowing continuing improvements to be made to the process;
- The strong SBIR brand, creating a sense of community through conferences and awards;
- Its phased model, focusing funding on the best projects, with amounts large enough for companies to get to a deliverable justifying subsequent transitioning into procurement of the resulting product and wider commercialisation;
- Its ability to provide significant funding through multiple contracts at an early stage in the development and commercialisation of new technologies.²⁷

The journey from Phase II contracts to commercial procurement is often lengthy and difficult. A series of measures have been put in place to lubricate this process. They include:

- Significant follow on funding through Phase II extensions and Phase III funding from non-SBIR budgets for innovations where agencies have a strong interest;
- Commercialisation training and consulting support for businesses;
- Initiatives to involve the larger defence contractors in the case of DoD.

The UK can learn from this experience and the Review has shown a clear need for Phase III funding.

²⁶ *Before Qualcomm: Linkabit and the Origins of San Diego's Telecom Industry*, Joe West, Associate Professor of Innovation and Entrepreneurship at the College of Business, San Jose State University.

²⁷ UK SMEs can also win multiple grants, but the amounts involved tend to be lower.

The history of Illumina (Page 30) raises the question of whether Solexa, the UK acquisition on which its success is based, might have been able to remain an independent, UK headquartered business, if SBRI contracts had been available to it on a similar scale.

Chapter 3 - The UK SBRI Programme

Chapter Summary

- There were two attempts to establish SBRI prior to 2008, both with little impact. The current model has been far more successful with usage increasing threefold since it was introduced. However, spending levels are still short of target and fell by 24 per cent in 2015/16.
- There are wide variations in approach between departments. There have been many successful SBRI. The NHS England programme is the best role model, with the cumulative present value to the NHS of its £73m expenditure since April 2014 forecast to rise to between £349m and £482m by 2022 and £1.2 to 1.9 billion by 2027. But many departments have only funded SBRI competitions reluctantly and on an ad hoc basis.
- In some cases, including the MOD, low levels of Phase 2 funding make the chances of projects getting to the stage where procurement is possible very unlikely. Some 84 per cent of SBRI projects came from departmental programmes with average contract values less than the minimum SBRI guideline.
- The SMEs who participated in consultations for the review generally have a very positive view of SBRI. Some regard it as the innovation programme best suited to their needs. However, there are concerns regarding barriers to procurement of the resulting products.
- The Northern Ireland Executive and Welsh Government have successfully used central funding models to increase use of SBRI across their public sectors.

SBRI History

There has been UK interest in the US SBIR programme for many years.²⁸ The Small Business Research Initiative was first launched as an attempt to imitate it in 2001, when Lord Sainsbury was Science Minister. This offered encouragement to government departments to advertise R&D contacts suitable for SMEs on an SBRI website, but there was little response until two of the Research Councils, BBSRC and EPSRC, launched small scale programmes. Between 2002 and 2006 the BBSRC made 43 single phase awards to small businesses, each worth between £150k and £300k.²⁹ The BBSRC SBRI was regarded as very successful and in 2014 one of the contract winners, Dr Curtis Dobson, received an award as BBSRC Innovator of the Year for his Manchester University spin-out company, Ai2, set up in 2005. However, Research Council SBRI were discontinued in 2006 after Research Councils UK concluded that funding businesses was outside their statutory authority.

A new approach to SBRI was announced in the March 2005 budget, aimed at delivering £100m of R&D SBRI contracts a year. This depended on departmental targets for SBRI spending, but with no allocated funding or proper monitoring. Again, the response from spending departments was poor and there are no identifiable SBRI competitions or awards from this period.

The Current SBRI Model

SBRI was relaunched in 2008 after further lobbying from entrepreneurs, scientists and venture capital investors.^{30,31} The model this time was much closer to the US SBIR. However, once again there was no defined budget. The Technology Strategy Board (now Innovate UK), along with the Department of Trade and Industry, was given the task of working with departments to deliver SBRI, and Innovate UK continues to play an important role in coordinating and supporting the programme. Defence and Health were identified as pilots to be launched in 2008/9 with a role out across government planned from 2009/10.

The key parameters for SBRI established at this time are shown in the box below.³²

²⁸ See for example: *The Enterprise Challenge: Overcoming Barriers to Growth in Small Firms*, Advisory Council on Science and Technology, 1990.

²⁹ BBSRC grant database.

³⁰ *MPs are asked to back programme of innovation for small businesses*. Letter to Financial Times, 19th October 2005.

³¹ *Secrets of the World's Largest Seed Capital Fund*, op.cit.

³² *SBRI; Government Challenges. Ideas from Business. Innovative Solutions*. Technology Strategy Board, 2009.

Key Features of the SBRI Model

- Competitive process to fund development of innovative science and technology based products and solutions to meet public sector needs as a customer or to address policy challenges
- Operates under the EU Pre-Commercial Procurement legal framework
- Any organisation can apply providing there is a route to commercialisation, but particularly appropriate for SMEs
- Phased to reduce risk and focus on best projects:
- Phase 1 Feasibility Study: typically £50-100k over 6 months
- Phase 2 Development and Testing of Demonstrator or Prototype: typically £250k-£1m over 18-24 months
- 100% funded contract, not a grant
- Awardee retains any IP, subject to limited public sector rights

The Department of Health pilot was focused on technology to reduce hospital acquired infections, and an NHS East of England SBRI competition, funded jointly by the NHS, the Technology Strategy Board and EU Structural Funds, was launched at roughly the same time.

There was no pilot MOD SBRI competition as planned. Instead it was agreed that competitions managed through the newly established Centre for Defence Enterprise would be treated as SBRI. Innovate UK provided £5.5m of support for MOD competitions between September 2010 and September 2012, 24% of all MOD SBRI contracts awarded over this period.³³

In order to deliver the planned roll out to other departments the small TSB/DTI team first approached their R&D teams. However, it became clear that most departments had R&D budgets that were fragmented, focused on academic research and policy studies, or pre-allocated to in-house teams, making it difficult for them to fund SBRI competitions.

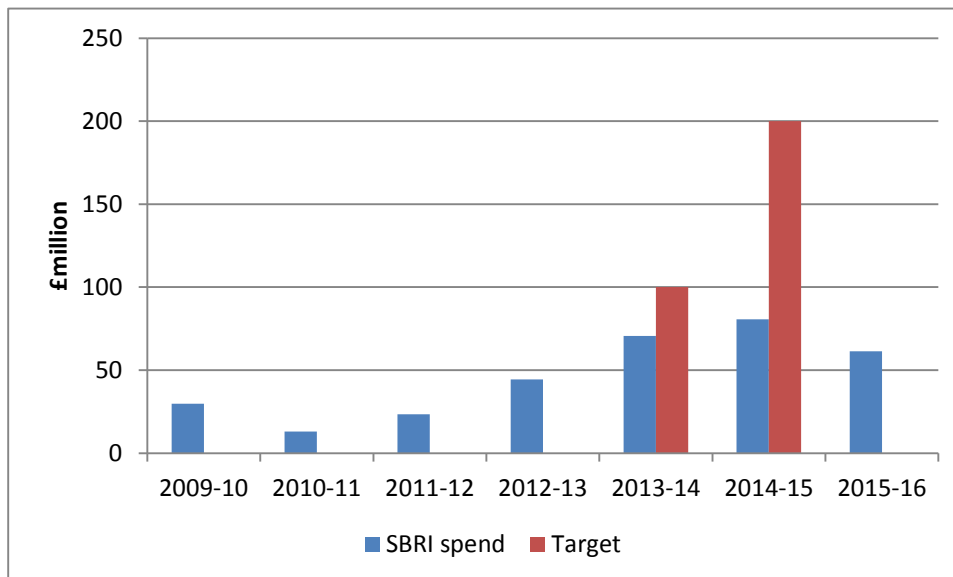
³³ A Review of the Small Business Research Initiative, Manchester Institute of Innovation Research with the Enterprise Research Centre and OMB Research Ltd, 2017.

There was also very little experience in most departments of managing technology development programmes (as opposed to research) and it was generally not seen as the role of departments to fund business R&D.

The role out of SBRI across government was therefore initially quite slow. However, the impetus began to build with increasingly strong support from the Treasury and Cabinet Office. In the March 2013 Budget an ambitious target was announced for SBRI contracts totalling £100m to be awarded in financial year 2013 -14 with £200m in 2014-15. Individual targets were set for six departments.

This represented an ambitious step up in spending, especially given the three-year funding cycle inherent in SBRI competitions. Even allowing for this, the response from departments was disappointing. After a Cabinet Office review of SBRI in November 2014, funding emphasis was switched from R&D to departmental procurement budgets, and their Commercial Directors, who are responsible for procurement, were encouraged to identify areas where SBRI could help address department needs for innovative solutions. This encouragement was reinforced by high level Cabinet Office and Treasury interventions with departments over the next two years and a wide range of SBRI competitions were initiated as a result.

EXHIBIT 2: SBRI EXPENDITURE SINCE RELAUNCH IN 2009/10



Source: Innovate UK management data.

The increase in the use of SBRI since 2010/11 is in large part due to the efforts of Innovate UK. Since 2009 it has built a small, dedicated team of six SBRI account managers, each with a portfolio of departments and agencies. Innovate UK continues to play a key role in the oversight and management of SBRI. Its responsibilities include promoting it to public sector bodies and helping them set up competitions, marketing them

to businesses and, where appropriate, helping to manage them. It has worked with over 80 public sector bodies, though only a minority of these ended up running SBRI competitions.

CASE STUDY 4: Owlstone – From Defence to Cancer Diagnosis

Owlstone was formed in 2004 by two PhD students, Andrew Koehl and David Ruiz, and Billy Boyle, a Research Assistant, who met at Cambridge University's Department of Engineering. Andrew had come to Cambridge from the US with the intention of using its student friendly IP rules to start a business. During his PhD he invented an improved, and greatly miniaturised, approach to chemical detection and analysis (field asymmetric ion-mobility spectrometry or FAIMS) using state of the art nano-fabrication technology. In essence this is a programmable "electronic nose" with multiple applications in defence and security, the oil, gas and chemical industries, healthcare and other sectors.

Owlstone raised \$2m from a small US based VC fund backed by high net wealth US citizens and, from an early stage, had a presence in both the UK and the US. The US presence enabled it to apply for US SBIR contracts and it won two Phase 1 awards. This rapidly led on to further funding from the US Department of Defense. During Owlstone's first five years it received around \$4m in DoD development contracts and a further \$1m in contracts from defence and security companies. This played a key role in funding the development of the technology platform and eventually led to major defence supply contracts. Other funding came from private individuals and investors in the US, alongside revenues from sales of FAIMS and ancillary R&D tools.

Owlstone's founders identified the potential to use FAIMS for non-invasive medical diagnostic applications soon after the company started. Although there was compelling pilot data showing the technology's applicability to a number of different indications, additional funding was required to demonstrate efficacy in a clinically relevant population. In 2014 NHS England awarded it Phase 1 and Phase 2 SBRI contracts worth £1.1m to fund clinical trials on the early detection of lung cancer. If successful, these are believed to offer the potential to save 3,200 lives and £82m in treatment costs a year in the UK alone.

The SBRI contract helped make it possible to establish a new company, Owlstone Medical, with Billy Boyle as Chief Executive, and it has since raised £19.3m of private investment. A second trial has been started on early detection of colorectal cancer, and an SBRI contract from the Innovate UK Stratified Medicine Programme helped fund initial work on therapy stratification for patients with severe asthma.



“SBRI funding has helped Owlstone Medical bring proven FAIMS sensing technology, originally developed for defence and industrial applications, to the medical sector. Bridging this gap has allowed us to pursue our vision to revolutionize the detection and diagnosis of cancer, infectious and inflammatory diseases. Our mission is to save 100,000 lives and \$1.5 billion in healthcare costs globally”

Billy Boyle, Chief Executive,
Owlstone Medical

Despite the encouragement of Downing Street and the Cabinet Office, and the strong practical support provided by Innovate UK, total annual SBRI funding has failed to reach the Treasury’s 2013-14 £100m target, let alone the 2014-2015 £200m target. Indeed, it moved into decline as this top-level pressure has lessened; in 2015/16 spending was 24% below its peak the previous year. The NHS England SBRI budget has been cut by nearly 40% from its peak and, at the time of the Review, successful SBRI programmes in several departments seemed unlikely to be continued.

I return to the reasons for this later in this chapter.

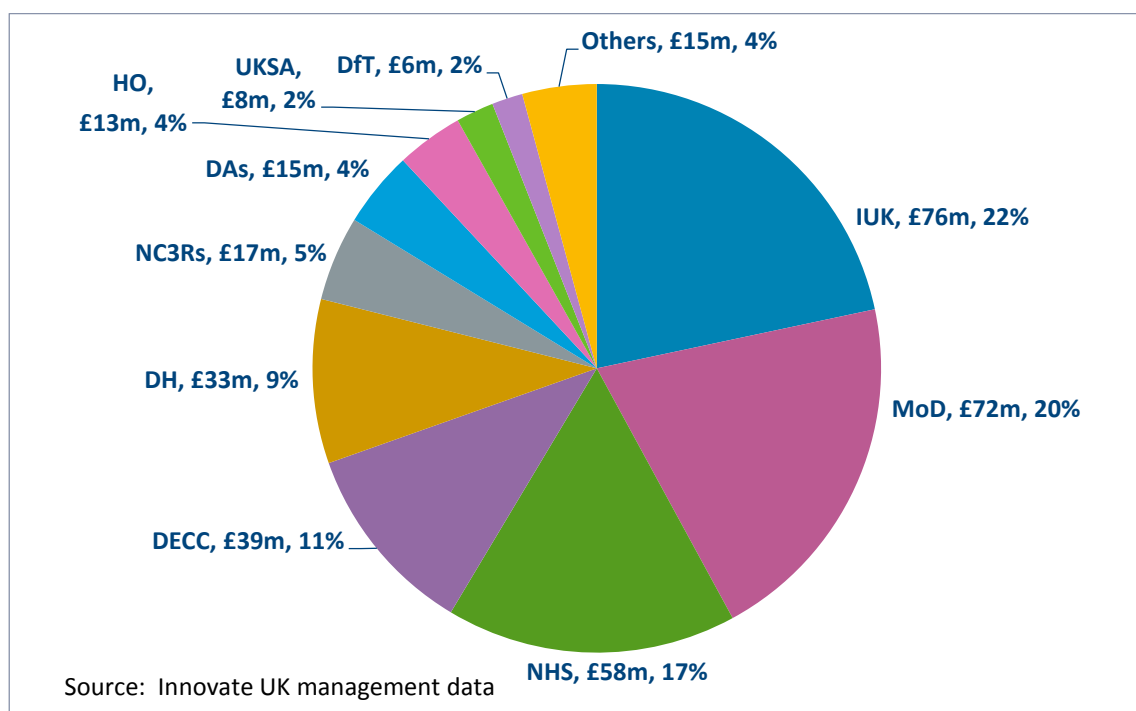
What the Data Tells Us – An Overview of SBRI Spending³⁴

Spending by Department

By October 2016, SBRI had provided £352m in funding to 2164 different projects. Around two thirds of contracts are estimated to have been directed at operational challenges and a third at policy challenges.³⁵

The largest portion of total expenditure, £76m, representing some 22%, came from Innovate UK. Although it is neither a customer for innovative technology nor has direct responsibility for spending department policy challenges, it has co-funded departmental SBRI's to help them start using the approach, and used it for some of its own challenge programmes.

EXHIBIT 3: BREAKDOWN OF SBRI SPENDING BETWEEN 2009 AND OCTOBER 2016 BY DEPARTMENT



³⁴ Innovate UK does not have automatic access to data on departmental SBRI programmes, and does not have comprehensive data on contract recipients. The analyses in this section are based on data gathered by Innovate UK and by the Manchester study updated to end October 2016. Some figures are based on a sample survey of SBRI recipients carried out in February, 2017. Sources are indicated in each chart.

³⁵ *A Review of the Small Business Research Initiative*, Manchester Institute of Innovation Research with the Enterprise Research Centre and OMB Research Ltd, 2017

The next largest department in terms of SBRI spending was the Ministry of Defence with 20% of the total, followed by the NHS with 17%. This is predominantly through NHS England. The Department of Health has also run occasional SBRI competitions, independently of the NHS, some with large budgets, and these are responsible for a further 9%. The Department of Energy and Climate Control (DECC, now part of BEIS) has also been a significant user of SBRI, with 11% of total spending, although at the time of the Review it had not run any competitions since 2014.

EXHIBIT 4: BREAKDOWN BY TYPE OF RECIPIENT AND COMPANY SIZE

		Proportion of contracts awarded (%)	Proportion of total contract value (%)
Firm size	Large	23%	25%
	Medium	13%	13%
	Small	23%	22%
	Micro	28%	27%
	Academic	12%	12%
	Public Sector	0.1%	0.1%
	Not for Profit	1%	1%

Source: Innovate UK management data; based on incomplete data.³⁶

SMEs won around 64 per cent of contracts, large companies 25 per cent and academic institutions 12 per cent. The split by value is similar. Unlike the US SBIR programme, both universities and large companies are eligible to apply for SBRI contracts under EU procurement rules. Businesses with less than 50 employees won 52% of contracts. This compares with 70% for the SBIR programme at the DoD, which has other funding streams for larger R&D projects more appropriate to established small companies.³⁷

³⁶ Data is not available for all competitions; 5526 applications with firm size information are included. Size is defined according to EU definitions based on the number of employees: large companies employ more than 249 employees, medium companies between 50 and 249; small companies between 10 and 49; and micro companies less than 10.

³⁷ In the US “small” companies are defined to be those having less than 500 employees, more in certain industries.

Two per cent of SBRI funding went to non-UK based firms. This is because competition sponsors saw these as offering the best solutions and is a bi-product of EU procurement rules. UK companies can, of course, apply for procurement contracts from other EU countries

The figures suggest that Phase 1 applications from both large companies and academics have been rather more successful than those of SMEs. This may reflect the number of rather speculative, or out of scope applications, received mainly from micro companies in many competitions, together with the experience of academics and managers in larger companies of making grant applications and business cases. There is anecdotal evidence from several of the main UK SBRI programmes that academic award winners find it very difficult to move towards commercialisation and in the NHS England programme, which makes awards after a “dragons den” interview process involving both business people and clinicians, rather few have won Phase 2 awards.

A better directed and managed SBRI programme should be expected to lead to an increase in the share of awards going to SMEs, particularly at the lower end of the size range.

Award Sizes, Success Rates and Number of Competition Phases

A vital feature of the SBIR and SBRI models is that contracts are of sufficient size to take successful projects to major deliverables milestones. By enabling companies to engage seriously with potential public and private sector customers for the resulting products and generate serious interest from potential partners and investors this can have a transformative impact on company prospects.

Many SBRI competitions have not conformed to this model and are unlikely to have led to successful outcomes from either a procurement or commercial point of view.

Application success rates are also important. These need to be low enough to ensure competitions are run on a competitive basis, but high enough to encourage companies to participate. Defining the desired outcome of competition projects in functional terms, so they are precise enough to attract firms that believe they have a potential solution, is a key part of a good SBRI process. Fishing expeditions tend to generate so many applications it is hard to judge between them, and unsuccessful applicants feel their time has been wasted. Some SBRI competitions have very low success rates, particularly at Phase 2.

Only 172 of the 258 reported SBRI competitions have followed the two-phase model, with average Phase 1 contract values of £67k and average Phase 2 contract values of £409k. Average Phase 1 and 2 application success rates were 20% and 30% respectively. Phase 2 success rates and average contract values were both significantly lower than for the US

SBIR (49% and \$964k respectively), but the difference becomes much more significant when individual departments are examined.

Roughly a third of recorded SBRI competitions have had a single phase rather than following the two-phase model. Some 27% only offered Phase 1 contracts, and 7% only “Phase 2” contracts.

MOD was responsible for 75% of Phase 1 only competitions, with an average value of £61k.

Competitions Outside SBRI Guidelines

Fourteen out of the twenty two departments and agencies that ran SBRI competitions between 2008 and 2016 either awarded no Phase 2 contracts or had average Phase 2s below the SBRI minimum guideline of £250k. This includes the MOD which was responsible for 42 per cent of SBRI funded projects overall. Of the 2164 SBRI projects that were funded in one form or another, only 345 (16%) were awarded Phase 2 contracts in two phase competitions with departmental averages above minimum SBRI guidelines.

Around half of these were in competitions funded by Innovate UK. NHS England and DECC (now part of BEIS) accounted for another 30 per cent.³⁸

Average Phase 2 contract values for the MOD and Home Office SBRI programmes were lower, and in the case of MOD much lower, than either the US SBIR average or the lower minimum SBRI guideline. Both also had very low rates of conversion from Phase 1 to Phase 2 compared with the US SBIR.

Whilst the low contract values for some projects are no doubt because the amount of work entailed in projects did not require more, the evidence suggests that the main reasons are departmental budget constraints and other funding priorities.

In evaluating the success of SBRI to date, it is important to factor in this consideration, particularly in relation to the extent to which contracts have led to procurement or commercialisation.

In its work with departments, Innovate UK has had some success in encouraging them to increase the number and funding level of SBRI Phase 2s in recent years. However, the problem remains. In the case of the MOD and Home Office, R&D budget restrictions and

³⁸ Based on data collected in a review of SBRI by Manchester Institute of Innovation Research, updated for this report.

CASE STUDY 5: ASV Global; How Three Engineers Turned Eight Years of Part Time, Largely Unpaid, Work into a Business Employing 80 People in the Following Six Years

Dan Hook, a newly graduated Naval Architect and two colleagues set up ASV in 2002 to develop unmanned autonomous marine surface vehicles. A £60k Smart grant enabled the founders to start work on a part time basis from their homes and garages, but it was another five years before they received their next funding, a contract from Dstl. Over the next three years small Dstl contracts totalling under £200k took ASV to the point where it had supplied its first vessel – a gunnery target boat - to a customer.



In 2010, eight years after the company had started, Dan Hook and Rich Daltry moved into the business fulltime. Two £750k contracts from major defence contractors, and orders for water quality measurement and the oil and gas industry followed. Each was structured on a develop, design and build basis, with phased milestones and an upfront payment of typically typically 25%.

In 2014 Phase 1 and 2 SBRI contracts totalling £380k, jointly funded by the National Oceanography Centre, part of the National Environment Research Council, and Dstl, enabled ASV to develop an energy efficient new vessel, the C-Enduro, for the research market. This is capable of operating in ocean waters over long distances for up to 30 days autonomously.

ASV has more or less doubled its revenues every year since 2010. It currently employs 80 people and has revenues of £10m.

"I am a great fan of SBRI. In the early days we developed all of our new products with lead customers. SBRI enabled us to create a vessel featuring new capabilities for a target market we had struggled to enter in this way, and at a time when we were focusing R&D on the oil and gas market with its rather different functional requirements. The Enduro also brought with it developments in energy harvesting and long range satellite communications that will help our wider product portfolio." Dan Hook, Cofounder, ASV Global.

"Oceanographic research at sea can be very costly so new technologies that are cheaper and more efficient are really attractive. SBRI has been a very effective way to identify and engage with new suppliers with novel solutions to our needs." Geraint West, Director of National Marine Facilities, National Oceanography Centre.

the wide range of challenges and technologies with which they have to deal, has led, understandably, to a strategy of focusing funding mainly on small, early stage projects.

Both the MOD and Home Office have some good examples of procurement and commercialisation, but the data suggests that their Phase 2 SBRI programmes are significantly underfunded compared with their potential. Following discussions with Ministry of Defence staff, I do not expect the MOD Innovation Initiative Fund or Defence and Security Technology Accelerator, announced in 2016, to change this position materially.

Departmental Variations in SBRI Approach and NHS Role Model

The way in which SBRI programmes are managed varies widely between departments. Appendix 1 summarises the approaches adopted by seven departments and agencies, together with those of the Devolved Administrations

Amongst the larger SBRI programmes, NHS England, DECC, DfT Future Rail, NC3Rs, and the MOD have all had SBRI management teams that have been in place for several years, with clear strategies and processes for managing SBRI with their own resources. The systematic way in which they approach the task, and the learning they have gained through successive competitions, is very apparent. In the case of DECC, DfT, Future Rail and NC3R other grant based funding models are also used.

In many other departments, competitions have been run intermittently and in an ad hoc manner. There is often weak championship, with individual management responsibilities varying over time and reliance on Innovate UK to carry out much of the competition management task on behalf of the sponsor. This can result in weak departmental ownership, poor problem definition and lack of procurement pull through.

The longest running SBRI programme is NHS England's, and its predecessor programme which started in the East of England.³⁹ It represents the single best role model for future programmes from other public sector organisations, though there are important features of other management approaches that could usefully be shared across government.

A review of the benefits to the NHS arising from its SBRI programme was commissioned by NHS England and undertaken by PA during the summer of 2017. It concluded that of the 176 projects awarded SBRI contracts since April 2012, 37 were already showing some deployment in the NHS, either through sales or clinical trials, and that these were providing it with up to £19m in annual savings, with rapid growth reflecting increasing take up. These were predominantly digital technologies with relatively short development times and no requirement for lengthy clinical trials.

³⁹ David Connell is a non-executive member of the NHS England SBRI Management Board.

The review also captured benefits to the wider public sector, with recurring annual savings from the nine most commercially advanced currently running at up to £30m.

When a further 14 projects, including diagnostics and therapies currently undergoing extended clinical trials were included, the report forecasts that the cumulative present value to the NHS will rise to between £349m and £482m by 2022, and to between £1.2 billion and £1.9 billion by 2027. This derives from total SBRI expenditure to date of £73m.

Additional impacts for the economy as a whole as of September 2017 were valued at £125m, including £14.6m from job creation; £6.4m from export sales; and £104m of private investment funding in SBRI backed companies.⁴⁰

Key Features of the NHS England SBRI Management Approach

- A programme board, including people from business as well as the NHS, and a permanent core team able to run all aspects of SBRI competitions;
- Access to NHS specialisms and potential customers through the regionally based Academic Health Sciences Networks;
- A systematic process for identifying future competition themes and defining challenges;
- The use of 'dragon's den' interviews at Phases 1 and 2, drawing on outside business and technical expertise as well as clinicians and NHS commercial managers to assist project selection, rather than relying on a paper based ranking;
- Contract terms ensuring long term access to progress monitoring information;
- Close monitoring of projects;
- Award transparency, a comprehensive website (www.sbrihealthcare.co.uk) and a publicly available annual report;

⁴⁰ Data from PA report for NHS England

Devolved Administrations Central Funding Models

The Devolved Administrations have all shown a great deal of interest in SBRI with the emergence of strong enthusiasts for the approach. Both the Northern Ireland Executive and Welsh Government have established central funds into which public sector bodies can bid on a competitive basis to run SBRI competitions. Scotland is also considering establishing a central fund. This approach has proved to be a very successful way of drawing out challenges and eliciting champions with a desire to make the process work. Companies from all over the UK (and elsewhere in the EU) are eligible to apply. This suggests that for most topics the Devolved Administrations are best advised to work with other UK agencies and a number of such collaborations have taken place.

Procurement Impact

The extent to which SBRI funded projects have resulted in product procurements by sponsoring departments is still rather limited, though there are good examples from the NHS, Border Force, NERC and other agencies.

It should be remembered, though, that only around 16% of SBRI projects were funded through competitions with average award sizes consistent with SBRI guidelines. Funding levels for most of the rest are unlikely to have taken them to the point where procurement is feasible.

Other factors include the long lead times associated with developing and testing innovative new products, securing regulatory approvals and customer interest, waiting for customer contacts to secure budget allocations and approvals within their own organisation, and in many cases integrating products into larger system level procurements. So it is still rather early in the programme to attempt a full evaluation.

At the same time, there are often cultural and administrative barriers to public sector procurement of innovative products whose value has already been proven. This is nowhere clearer than in the NHS. Though the NHS England SBRI's has probably led to the procurement of more products than any other SBRI programme, the amounts involved are small and restricted to a few locations. Dissatisfaction with the NHS' commercial procurement process continues to be widespread. The problem is well recognised by NHS management and the final report of the Accelerated Access Review published by the Government in October 2016, offers some solutions. The Government announced a series of measures as a "first step" in taking it forward in July 2017.

Some SBRI backed healthcare companies are therefore focusing first on the US market. An example is 11Health, started by Michael Seres, the 11th full intestinal transplant patient in the UK, and already a successful entrepreneur. 11Health has developed a digitally connected ostomy bag enabling users to "avoid surprises" and improve their quality of life.

It also allows hospitals to save around £4000 per patient a year through a 30% reduction in readmissions. 11Health has found the NHS process for setting up clinical trials and gaining NHS tariff approval complex and ill defined. Interest amongst US hospitals has been much greater and by 2015 there were already 300 patients using the device there. On the back of this, the company was able to raise \$5.5m of venture capital to scale the business from US investors, including Sir Michael Moritz, backer of Google, PayPal and Skyscanner. UK based VCs turned down the investment because of lack of significant sales.

Proposals to improve procurement take-up across departments, including a new SBRI Phase 3 are included in Chapter 6 of this report.

Departmental Feedback

Amongst departmental SBRI management teams interviewed for the Review, most expressed strong support for the programme as a valuable way of identifying and addressing the challenges facing departments and accessing innovative solutions from SMEs outside their traditional supply base.

However, the attitude amongst many senior budget holders is more complicated. Most believe that it is the responsibility of BEIS to fund innovation. Their focus on procuring “off-the-shelf” and finding short term fixes for operational challenges, means they are reluctant to fund SBRI, especially as only a proportion of projects are likely to succeed and the benefits often arise after several years. Targets and government pressure to use SBRI have frequently resulted in ad hoc responses, without real ownership.

The internal pressure to spend limited R&D budgets on a mixture of research on the one hand and off the shelf procurement of already available products, is perhaps most clearly apparent in the MOD and DoH/NHS. It is also understandable given the financial constraints on both.

There may also be a cultural element. It is possible that the traditionally high level of support for (and experience of) academic research within the Civil Service, has tended to put support for engineering, product development and entrepreneurial innovation in second place when it comes to funding. The US and German cultures tend to put greater emphasis on engineering and the role of businesses within the innovation system.

Despite the reservations of the Commercial Directors and senior budget holders we interviewed, most volunteered a wide range of areas where SBRI could help improve public sector cost effectiveness if ring-fenced funding were available from outside their departmental budgets.

Royal Academy of Engineering Submission to SBRI Review

“For small innovative companies, being awarded a contract from real customers can help their own feasibility as functional companies, including by demonstrating a revenue flow. Unlike funding from many innovation grants, the contracts awarded by SBRI cover full costs and do not require match funding from another source, factors which are appealing to small companies.

The overall consensus is that SBRI has been significantly underutilised. Action needs to be taken to increase the use of SBRI across all appropriate government departments and agencies.

SBRI appears to operate in a largely one directional manner, requiring the identification of problems by government departments and agencies for which they have an appetite for innovative solutions. Forums in which companies and entrepreneurs can present innovative ideas should be encouraged. Such activities could then be used to shape SBRI competitions.”

The Business Perspective

Company Usage Patterns

The situations in which companies have benefitted from SBRI fall into a number of different categories.

In some cases, SBRI contracts have triggered the creation of a new product company, which has gone on to win further public sector funding and venture capital. Owlstone Medical is a good example. In others it has played a significant role in demonstrating a platform technology opening wider applications. Fuel 3D, awarded an SBRI contract by NHS England and RepKnight, funded by The Home Office are both examples. (See Appendix 1).

For companies with a profitable consulting business model, based on using their skills to undertake design and development contracts for different clients, SBRI offers a way of building a more scalable product business on the back of their existing consulting operations over a timetable that is longer and more consistent with the timescales over which the markets for disruptive products tend to be created. As discussed in Chapter 5, this “soft company” model is an important route to creating new ventures.

ADI, based in the North East, the Imagination Factory, based in London, and Plextek, based near Cambridge, are all companies that are pursuing this strategy. ADI has already begun to make the transition; its SBRI funded PainSense product has growing sales from the NHS and the company has built on the resulting credibility to generate revenues from a second product, also for the NHS, and with bigger potential.

Plextek, a specialist wireless and sensor consultancy, founded in 1988, has already spun off three successful product businesses: in connected street lighting and city wireless networks; vehicle telematics; and ground based radar systems, all built up over the last ten years using this model. Plextek's Chief Executive plans to repeat the process. The MOD has been an important customer over the past decade and a current major network communications project with Dstl offers the potential of creating a significant new business serving both defence and commercial markets. The twenty or so small scale, earlier stage contracts it has undertaken for CDE have so far not taken the projects involved to the point where the company could progress the most promising of these with its limited internal funds. It does not regard the traditional range of Innovate UK cost sharing grants as a suitable alternative source of funding for a company with its business model.

Company and Public Consultation Feedback

Association for Innovation, Research and Technology Organisations Submission to SBRI Review

“Many SMEs rely on grant funding for their innovation activities. SBRI as a full cost contract brings a different mind-set to the SME and moves it from dependency towards maturity, with focused deliverables.

Equity investors generally seek companies with demonstrable revenues from contracts. The ability to demonstrate such revenues, including from SBRI, increases the likelihood of being able to raise private funding.

Sectors where there is an effective or near monopoly in the UK market in terms of procurement, such as health with the NHS mean there is only one significant early adopter client.

AIRTO believes the SBRI mechanism should be used more widely than the current range of contracts placed.”

Businesses highlight a number of advantages SBRI offers compared with other innovation programmes, including:

- 100% funding, frequently mentioned as a key benefit, both by micro and small businesses (i.e. those employing less than 50 people) and by larger businesses for which SBRI made riskier R&D projects more feasible;
- Retention of IP, also regarded as a critical advantage, allowing businesses to continue to work on products after SBRI projects have finished;⁴¹
- The market pull implicit in SBRI and the fact that there was potential for a first customer for the resulting product;
- The interest created in their markets as a result of SBRI publicity.

A number of firms believed that SBRI was superior to other government innovation programmes, both in terms of process and design.

The main weakness of SBRI highlighted in company feedback was the weak pull through to procurement of successful product developments. This related to both competitions that took very few projects through to Phase 2 and to more substantial SBRI competitions.

Companies that had benefitted from health and social care SBRI competitions had in nearly every case found it difficult to navigate through the clinical trial, operational testing, approval, listing and procurement processes. There was a unanimous call from companies operating in the UK health sector for a Phase 3 to help address this problem. I return to this issue in Chapter 6.

A fuller analysis of the Review's consultations with businesses is included in the BEIS Annex published with this report.

Key Lessons for Improving SBRI

There is a great deal of support for SBRI from SMEs. At its best it is a powerful way of delivering new technologies to meet public sector needs and provide a "first break" to set companies on a growth trajectory. At the same time, SBRI usage is highly variable across government, both in terms of programme management and funding levels. Many departments see it as BEIS's job to fund innovation in businesses, rather than theirs. Given other pressures on their budgets, and for very understandable reasons, they mainly

⁴¹ Companies also retain IP created in R&D funded by Innovate UK grants. The comparison here is with contracts for private sector customers who frequently acquire the IP in the process.

expect to buy innovative products *off-the-shelf* as and when they become available, rather than fund developments which may not ultimately be successful.

The ASV Global case study shows the impact that a government contract can have on a company's credibility, but it also highlights the limited impact of drip-feeding small scale grants and contracts. SBRI contracts need to be of similar in size to the US SBIR if they are to be transformational.

A reinvigorated SBRI needs to address the following challenges:

- It must stimulate and harness spending departments' appetite for innovative solutions in a way which is consistent with their funding priorities and pressures. Funding for SBRI is a major issue;
- SBRI programme management processes must be designed to deliver innovations that departments want and are able to procure;
- It must move closer to the US model in terms of project funding levels;
- It must be configured in a way which is appropriate to the UK's much smaller public sector budgets, (and proportionally smaller number of businesses). To do so it must be better than the US SBIR at focusing on projects and businesses with the best chances of delivering successful procurement and commercialisation outcomes. Achieving better procurement outcomes requires the adoption of best practice innovation programme management approaches that engage with potential users, specifiers and purchasers throughout the SBRI process.

Chapter 4 Relationship between SBRI and Other Innovation and Procurement Policies

Chapter Summary

- SBRI represents less than 3 per cent of the combined value of business R&D funding from R&D tax credits, Innovate UK R&D grants and SBRI contracts;
- Most UK government support for business R&D comes in the form of subsidies and operates by reducing its cost to stimulate a growth in supply. In contrast, SBRI operates by providing increased demand for R&D, from public sector customers with a defined need;
- SBRI's 100% contract funding and other features make it particularly appropriate to start-ups and SMEs without venture capital, and for whom R&D tax credit receipts are small and the need to fund a proportion of project costs alongside grants can be a challenge;
- Successive governments have tried since 2000 to introduce policies to encourage Public Procurement of Innovation ("PPI"). So far SBRI is the only one to have gained traction;
- To deliver its full potential from a procurement point of view a much more strategic, "open innovation" process must be embedded within departments and agencies running SBRI programmes.

In examining the role that SBRI has played in the UK so far, and the role that it could play in the future, it is important to set it in the context of other policies with similar aims.

SBRI combines two sets of objectives: by fostering innovation to support economic growth, particularly from SMEs selling innovative products in the UK and abroad; and to help spending departments increase their cost effectiveness and meet other policy objectives, including increased procurement by SMEs.

I examine how SBRI relates to other policies under each of these headings in this Chapter.

Relationship between SBRI and the Broader UK Innovation Policy Landscape

The range of business R&D funding from different parts of the public sector is complex. The full picture is rarely brought together to enable the balance of expenditures across government to be optimised for maximum impact.

It is not the purpose of this Review to cover all these policies and programmes. Instead it focuses on the primary mechanisms delivering government funding support for business R&D.

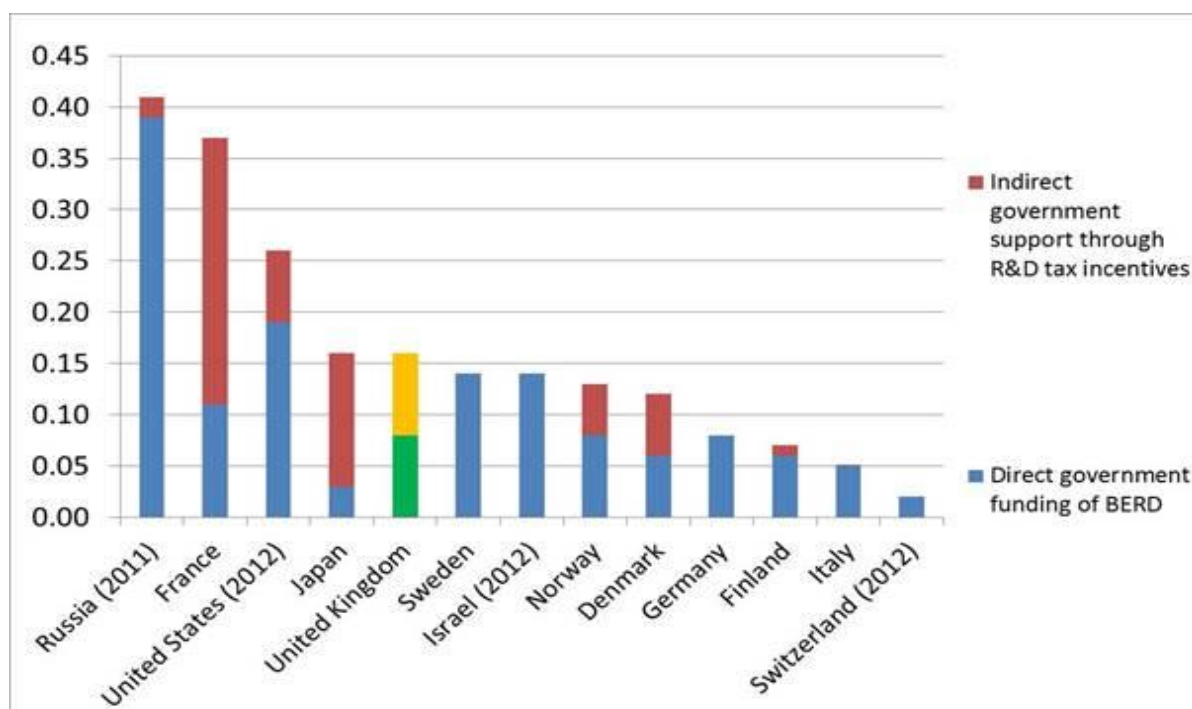
By way of context, R&D expenditure is relatively low in the UK compared to many of our competitors. This applies to both total R&D and R&D undertaken by businesses. This is known as Business Enterprise R&D (BERD). It was 1.1% of GDP in 2015 in the UK, compared to 1.9% in France, 2.0% in the US, 1.9% in Germany and 2.7% in Japan.⁴²

As shown in Exhibit 5, OECD statistics indicate that UK government funding for BERD is somewhere in the middle of the pack at 0.16% of GDP, but less than half that of the highest countries. In 2013 around half of UK support came through R&D tax credits, and around half through direct government funding. Since then rule changes have led to a 38% increase in the overall value of UK R&D tax credits.⁴³

⁴² OECD Science, Technology and Industry Scorecard 2015.

⁴³ As Exhibit 5 shows, though many OECD countries have R&D tax credit programmes, UK R&D support to business is more dependent on them than some of our closest industrial competitors. Historically much of Germany's support for business R&D has been provided indirectly to German businesses, through its network of 69 Fraunhofer Institutes which provide R&D services to industry. Federal and State funding, including base funding, projects and contracts, was around €1.2 billion in 2015, about 60% of total Fraunhofer revenue. (*Fraunhofer Gesellschaft Annual Report 2015*). This underpins the closer to market contracts they undertake for companies. US Federal R&D tax credits are largely linked to growth in companies' R&D spending, rather than absolute spending as in the UK. Based on US and UK government statistics US R&D tax credits represented 2.0% of total industry R&D expenditure as opposed to 7.5% in the UK. (*Creating Markets for Things that Don't Exist*, David Connell, Centre for Business Research, 2014.)

EXHIBIT 5: COMPARISON OF GOVERNMENT FUNDING FOR BUSINESS ENTERPRISE R&D AS PERCENTAGE OF GDP (2013 EXCEPT WHERE OTHERWISE STATED)



Source: OECD Data

There are four main UK government innovation funding mechanisms designed to encourage increased business R&D spending:

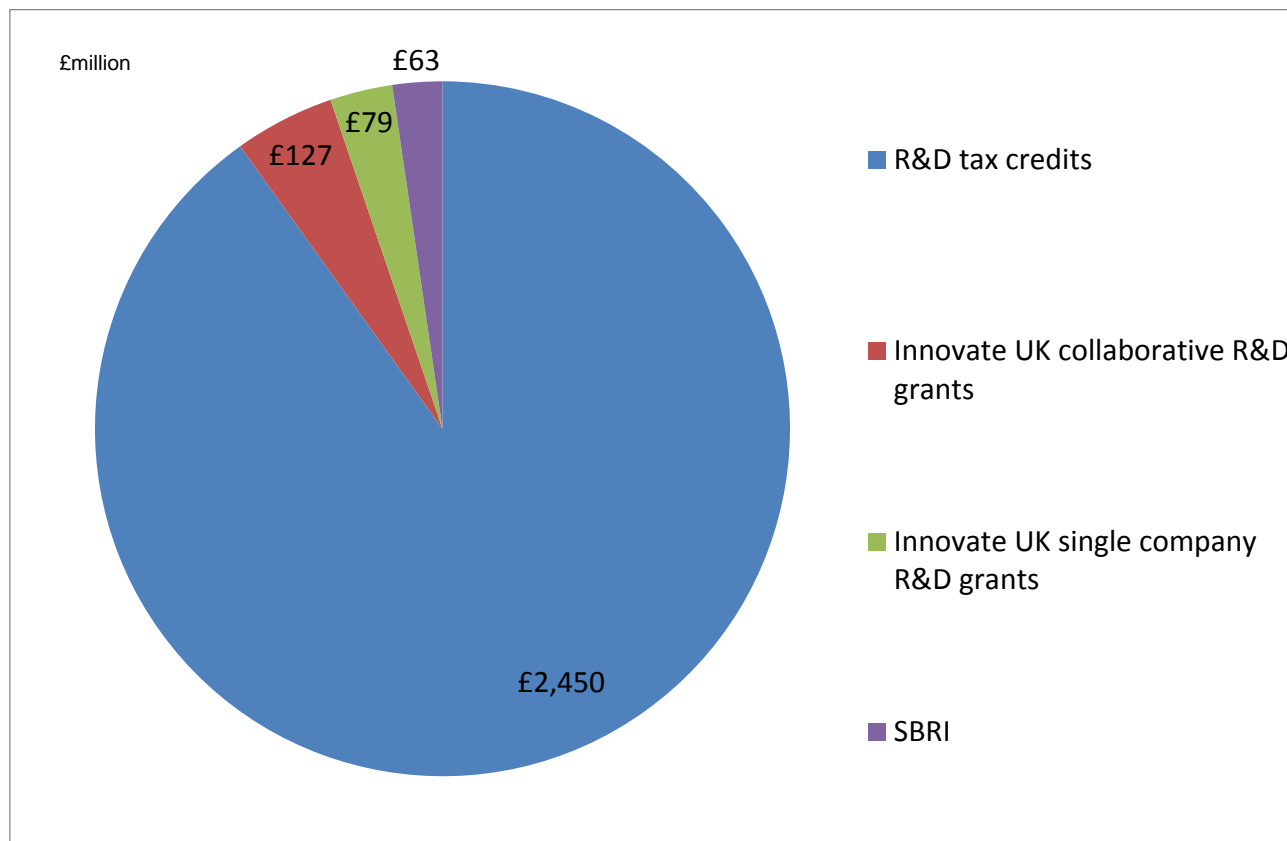
- R&D tax credits, administered by HMRC (claims valued at £2.45bn in 2014/15)
- Collaborative R&D grants awarded by Innovate UK (operational spend of £170m, of which £127m went to businesses in 2015/16)⁴⁴
- Single company grants, including Smart (operational spend of £80m, of which £79m went to businesses in 2015/16)⁴⁵
- SBRI, coordinated by Innovate UK, but awarded by a range of departments (£63m spend in 2015/16)

⁴⁴ Source: Innovate UK. The data includes £9m of EU funding requiring collaboration with at least one EU partner.

⁴⁵ Source: Innovate UK. The data includes £48m spent on Smart grants, which are no longer offered by Innovate UK.

Innovate UK also spent around £214m on other programmes outside of its core grants, indirectly supporting R&D in UK businesses.

EXHIBIT 6: SELECTED UK GOVERNMENT POLICIES PROVIDING R&D FUNDING TO BUSINESSES (EXPENDITURE IN £ MILLION)



Source: Innovate UK data (15/16), and HMRC Research and Development Tax Credits Statistics, 2016 (for FY14/15)

R&D Tax Credits

R&D tax credits were first introduced just for SMEs in 2000. Since then there have been a series of changes to extend the scheme to large companies and make it more generous. In 2014/15 the cost of the programme was £2.45 billion. Average support rates are currently worth around 26p in the pound for SMEs and 9p in the pound for large companies.

R&D tax credits are relatively simple to claim, pay quickly and do not require extensive competitive processes or involve government in backing winners.

The basic philosophy behind the R&D tax credits policy is that by making R&D cheaper to undertake, companies will do more of it. It is also seen as an important incentive, along with the strength of UK science base, for companies with geographically mobile R&D programmes to undertake them in the UK. Indeed 51% of UK business R&D is now undertaken by foreign owned companies.⁴⁶

The key limitation of R&D tax credits from the point of view of this Review is that for start-ups and SMEs without significant cash reserves or venture capital, they do not provide a sufficient injection of cash to have a transformative effect on R&D spending. Two common scenarios illustrate the point:

Example 1

A one year old start-up team with say £100k of founder's capital and sweat equity (i.e. working without payment) would expect to receive up to £26k in R&D tax credits (2017/18). Together with tax relief at the standard Corporate Tax Rate (19%), the total relief would be £44 for every £100 of R&D expenditure. Businesses not in profit could claim up to £33 payable credit for every £100 of expenditure. This is likely to be inadequate, on its own to fund the development of a product.

Example 2

A company that has grown to 50 people and £5M annual revenues with minimal external investment will probably have a relatively low level of profitability, say 5%, because of the continuing cost of investing in the growth of the core business. It might be able to invest say 5% of turnover a year on R&D, that is to say £250k, most of which must be focused on refreshing and extending its core business. The additional R&D tax credits, on their own, are unlikely to be adequate to fund the development of a new product.

Collaborative R&D Grants

Collaborative R&D grants (CR&D) have been a mainstay of UK innovation policy since the early 1980s. It is also the favoured form of innovation support under EU State Aid Rules.

The aim of collaborative R&D grants is to:

- Encourage greater collaboration between businesses; and between businesses and academia;

⁴⁶ *Business enterprise research and development statistical bulletin, UK 2015*. Office of National Statistics.

- Support projects which are likely to result in additional innovation, improve capability and increase economic growth.

There have seen significant changes in the focus of CR&D since the Technology Strategy Board (now Innovate UK) took over responsibility from the Department of Trade and Industry, and SME participation has been greatly increased from around 30% between 2008/9 and 2010/11 to 56% in 2015/16. University participation levels have remained broadly unchanged at 18% in 2015/16.

In 2015/16 £172M of CR&D grants were awarded.

CR&D projects tend to have many partners. The most recent (2011) evaluation indicated that 58% of projects had four or more partners and roughly 69% had one or more academic partners. 71% of projects last for more than 2 years.

In 2015/16, the median size of Innovate UK core grants (covering both CR&D and single company programmes) was £100k per project and £75k per participant.

The CR&D model is particularly appropriate for exploratory developments involving multiple partners where they can be funded to do work in parallel over a long period. As a result, this funding model is easier to use for larger businesses or those with venture capital backing, with an ongoing longer term R&D programme around which a grant project can be configured. A more contractual (as opposed to collaborative) model, with a lead business and subcontractors or consultants if required, is usually the model used by innovative businesses for development projects for customers and in-house projects.

Single Company Grants

Under various names, single company grants, which do not require collaboration, have been available since the 1990s and they have been generally well regarded by SMEs. They have grown as a proportion of overall Innovate UK grant funding in recent years. Innovate UK's family of single company grants were until 2015/16 primarily delivered through a programme called Smart. Smart has now been discontinued as a separate Innovate UK programme, but single company grants will continue to be used as part of the mix.

Single company grants tend to be appropriate for companies with specific new product ideas. Different stages in the product development process have been supported by the different flavours of grants, from "proof of market" through "proof of concept" to "prototype development", though, unlike SBRI, there has historically been no mechanism for successful firms to get sequential grants to move through these phases in anything like a seamless manner.

For most technologies the amounts involved are insufficient to get to a marketable product, though they may be able to advance development to the point where private sector investment or contracts with corporate customers can be secured.

Current Innovate UK Grant Programmes

In 2016 Innovate UK reorganised and streamlined its approach. Competitions are now organised around four sector groupings and an “Open” funding stream aimed at high growth opportunities that do not fit these sectors.

The four sector groupings are:

- Emerging and Enabling Technologies – technologies and capabilities that will lead to new products;
- Infrastructure Systems – global opportunities in transport, energy and urban living;
- Health and Life Sciences, including agriculture and food, underpinned by biosciences and medical research, and enabled by engineering and physics;
- Manufacturing and Materials, focusing on advanced manufacturing.

A combination of collaborative and single company grants will be used.

The process for selecting and awarding Innovate UK grants will continue to be based on external reviewers and a points system in which applications are awarded to those accumulating the highest number of total points against various categories.

Current support rates for different stages in a R&D project are shown below.

EXHIBIT 7: SUPPORT RATES FOR INNOVATE UK R&D GRANTS

Applicant Business Size	Fundamental Research	Feasibility Studies	Industrial Research	Experimental Development
Micro/Small	100%	70%	70%	45%
Medium	100%	60%	60%	35%
Large	100%	50%	50%	25%

Source: Innovate UK

The subsidy rate for experimental development, which covers a high proportion of the business R&D needed to create a product, is between 35% and 45% for SME's. For

companies without other revenue streams or investment, providing co-funding can raise difficulties. As it is a contract, SBRI can provide 100% funding.

EU Innovation Programmes and the SME Instrument

Alongside UK government policies to fund R&D in companies, we also need to take note of EU programmes. In the first two and a half years of the Horizon 2020 programme the UK received around €2.6 billion of EU funding, of which €564M (around £205m per annum) went to private companies, including €347M (£126m per annum) to SMEs.

Most of this was through complex, multi-partner collaborations, which, despite their participation, have generally been rather unsuitable for SMEs. However, the Commission has put a good deal of effort into making EU programmes more SME friendly in Horizon 2020, most notably through a new “SME Instrument”. A third of UK SME funding from the EU has since been through this scheme.

The SME Instrument was launched in 2014 in response to a proposal that it commit €7 billion of the Horizon 2020 budget to co-funding nationally led US-style procurement based programmes open to all EU companies. Subsidiarity considerations made this impractical and so the SME Instrument instead offers an ‘SBIR inspired’ solution using grants, but without requiring collaboration. Like other EU programmes, selection is made by a panel of reviewers based on written submissions. The budget for the SME instrument is around €3 billion over the 7 years of Horizon 2020 and it funds SME R&D projects in two phases, each covering 70% of project costs:

- Phase 1: (feasibility assessment): €50,000 lump sum;
- Phase 2: (innovation, development and demonstration): typically €500k to €2.5M.

In the 2½ years to June 2016, 197 UK companies won a total of €10M in Phase 1 grants and a further €100M in Phase 2 grants, making total funding comparable to the UK’s own Smart programme, but with grant support rates that are much less demanding on SMEs. Success rates were 12% at Phase 1 and 6% at Phase 2, showing the popularity of the programme.

The approach adopted by the SME instrument was specifically enabled in the Horizon 2020 regulations and would otherwise be at variance with EU State Aid Regulations. This precedent should enable a more flexible approach to be adopted by Innovate UK in its own grants.

Other Government R&D Support and Funding

Although R&D Tax Credits, Innovate UK and EU Grants and SBRI represent the key policies for funding R&D by SMEs, there are other funding and support programmes. They include Innovate UK's Catapult Centres, the well regarded Knowledge Transfer Partnership scheme, and a range of networking, information and communication activities. Operational spending outside its core grant programmes and SBRI came to around £214m in 2015/16.

Spending departments also funded around £1.7bn of business R&D, with the Ministry of Defence, accounting for around £1.5bn. The remaining £230m may include research studies and advice on government policy rather than technological orientated R&D.

Why SBRI is Different

Both R&D tax credits and Innovate UK grants programmes are essentially subsidies, based on the principle that reducing the cost of R&D will encourage companies to do more. In other words, they act on the supply of R&D. Because UK grants require a company contribution to project costs they are appropriate for companies that are in a position to provide this, from existing revenue streams, retained profits or money raised from investors or lenders.

In contrast SBRI is designed to increase the demand for R&D.

It also has other differentiating features:

- It is an outcomes-based contract, enabling development projects to be tied to clear customer needs and bringing greater credibility than grants;
- It is phased to manage risks, and through an early evaluation of an awardee's ability to deliver the project and build a successful business, it focuses funding on the most promising projects;
- It provides 100% funding, allowing innovation projects to progress in SMEs that have not raised venture capital, and without having to spend the considerable time and energy required to do so before a new product idea is well validated;
- SBRI contracts do not require collaboration;
- SBRI is designed to be transformative, with Phase 2 contracts large enough to take projects to a key milestone over up to two years. SBRI guidelines specify contract values designed to be significantly larger than most Innovate UK single company grants.

Value for Money of SBRI Programme

The BEIS Annex published with this Review reports on the results of an evaluation of SBRI undertaken by the Manchester Institute of Innovation Research based on a survey undertaken in 2014 and 2015. The evaluation found relatively high levels of additionality, and, even at this early stage, concluded that the direct benefits of SBRI were greater, on a discounted basis, than the costs of the programme. However, it concludes that the data available is of insufficient quality and completeness for robust evaluation and effective monitoring. Like similar reviews of Innovate UK grants the evaluation relies on self-reporting of future jobs created or secured.

Attempts to make a robust quantitative evaluation at this stage are also complicated by the fact that SBRI has not been run as a unified programme, with average project values in over half of the departments that have used SBRI below minimum funding guidelines. Furthermore, Phases 1 and 2 combined are typically expected to last 2 years or more, with, regulatory approvals, if required, and purchasing taking place later. So, in many cases, it is unlikely that clear project success or failure, and hence the full economic impact of SBRI could have been detected at the time of the Manchester survey.

The BEIS Annex to this report recommends that a new approach be adopted for future evaluations of innovation programmes like SBRI.

Relationship between SBRI and the Broader UK Procurement Policy Landscape

Procurement improvement is one of the government's "ten pillars" for delivering the Industrial Strategy. The Green Paper emphasises how taking a strategic approach to annual public sector spending presents opportunities 'to support investment in innovation and skills, strengthen UK supply chains, and increase competition', thereby achieving value for money and strengthening the economy.

Government has tried to encourage Public Procurement of Innovation (PPI) since the early 2000s. Before discussing how a revitalised SBRI could help deliver this objective, it is first necessary to examine the mechanisms that have been tried previously

History of UK Innovation Procurement Policies

Forward Commitment Procurement (FCP) was launched in 2006 to give potential suppliers information on the requirements and future needs of customers, communicate procurement plans in advance, describe the outcomes sought, rather than focusing on availability or affordability, and facilitate communication between challenge owner and suppliers. A small number of successful "pilot projects" are recorded, including diverting

prison mattresses from landfill, and installing ultra-efficient lighting at an NHS Foundation Trust. However, no subsequent FCP projects have been publicised and it is not being actively promoted.

In 2009 departments were asked to produce **Innovation Procurement Plans (IPP)**. Whilst these documented existing innovative procurement practices, they were not a success. The quality of the plans varied widely; departments often did not identify specific opportunities to effectively pull-through innovation. A lack of measureable objectives meant it was difficult to assess whether a department had delivered what it stated it would. IPPs were discontinued under the Coalition Government of 2010 - 2015.

The longest running and most well-known PPI mechanism is SBRI. SBRI formally falls within the EU Pre-Commercial Procurement (PCP) framework. PCP is a more general, phased mechanism for funding the development and trialling of innovative products. SBRI defines a specific process and gives guidance on contract values based on the US SBIR. As a research and development contract, at least 50 % of an SBRI contract value must be attributed to R&D services; and the SBRI challenge must be advertised openly prior to Phase 1. Any commercial procurement of a product developed through SBRI must first be advertised via an open competition.⁴⁷

The Innovation Partnership (IP) is a new EU procedure, allowing for the combination of “research” and procurement. It was introduced in 2015. With a competitive phase at the start, IPs are designed to cover the entire procurement process for an innovative solution to a public sector challenge from development to commercial purchasing. Unlike the PCP procedure, under the IP rules a commercial procurement of the best solution can follow pre-commercial funding **without a competitive process**. Concern over detailed implementation issues have led to only one example of Innovation Partnerships in the UK so far, though it could be a useful alternative to the PCP procedure for running SBRI competitions in some cases.

Increasing SME Participation in Public Sector Procurement Generally

Government has long sought to make it easier for new suppliers to access public sector markets and increase SME participation. It has committed to spend £1 in £3 with SMEs by 2020. In July 2016, Emma Jones was appointed Small Business Crown Representative to help further break down the barriers they faced in selling to government. SBRI can

⁴⁷ Beyond pre-commercial procurement, commercial procurement for the UK public sector is governed by the Public Contract Regulations 2015 (PCR). These are based on 2014 EU legislation designed to ensure the EU public procurement market is open and competitive, and that suppliers are treated equally and fairly.

contribute to achieving these wider targets, particularly through procurement from STEM based companies with export potential.

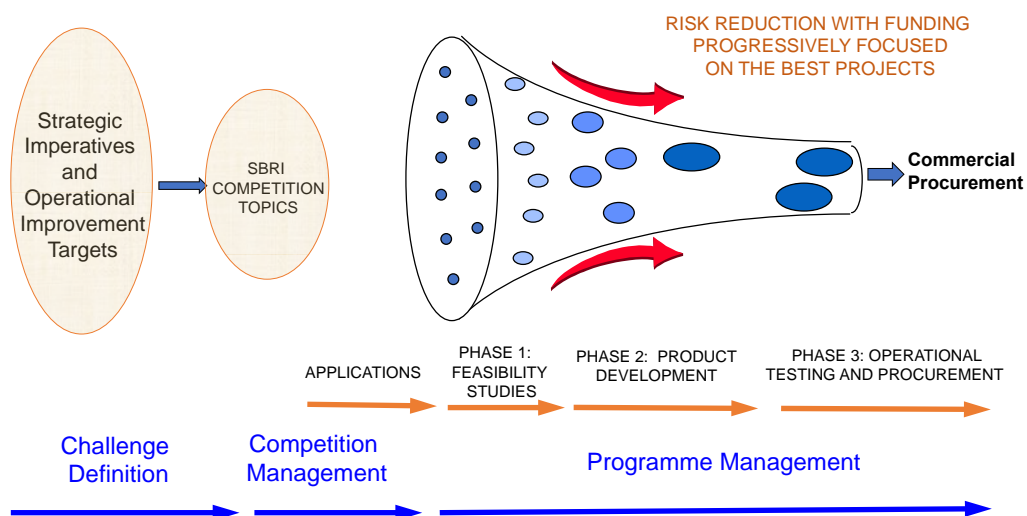
Embedding Innovation within Spending Departments

Previous policies to encourage innovative procurement have been largely concerned with offering specific procurement tools which spending departments and agencies were invited to use. But having access to a set of tools on its own is of little value if you don't have a plan for using them. To achieve a more fundamental improvement in the openness of government to innovation we need to learn from the private sector.

Operating in competitive markets, large corporations face similar challenges. The increasing rate and complexity of technological change means they must be continually searching for new innovations from outside. And like all large organisations they can suffer from “not invented here”, cost pressures and other barriers to adopting new ideas. As a result, many have introduced “open innovation” models to identify, test and apply externally developed technologies, including funding product developments as a lead customer.

SBRI is essentially an open innovation process. Its key features, illustrated in Exhibit 8, mirror the *innovation funnel* often used to describe private sector innovation management approaches.

EXHIBIT 8: SBRI PROGRAMME MANAGEMENT



There are five key aspects of the approach:

- Systematically identifying areas with innovation potential and future procurement windows by looking at infrastructure plans, major cost headings, internal department projects and other targets, objectives and problems. SBRI campaigns can then be run to address these;
- Within these areas, identifying and defining specific challenges in terms of desired outcomes, based on major cost areas, and opportunities for improvements that cannot be achieved by procuring off-the-shelf products. This should include opportunities for process re-engineering to deliver whole system improvements that could be enabled by innovative technology;
- Identifying businesses, including non-traditional suppliers, with whom exploratory discussions can be held to inform competition design;
- Involving key stakeholders throughout the process from problem definition through to testing and trial procurements, including users, decision makers, budget holders and, if appropriate, other participants in the supply chain;
- A programme management approach that addresses key risks and uncertainties early, and progressively focuses increasing amounts of funding on the projects most likely to deliver. Each decision to progress must take account of:
 - technical progress
 - likelihood of the solution addressing the challenge cost effectively
 - system integration issues
 - level of user and budget holder interest
 - barriers to procurement and implementation time scales
 - a company's ability to complete the project and make the resulting product commercially available.

To transform the public sector's ability to use external innovations to drive improvements in cost effectiveness and service quality, open innovation processes of this kind must be embedded within spending departments and other agencies. By adopting this systematic methodology, SBRI could also encourage outcome based thinking generally, identify opportunities for innovation that do not involve funding product development, and help drive wider cultural change.

To make SBRI effective, it must be managed by individuals with the necessary innovation programme management experience and capabilities. And it must involve key stakeholders at each stage in the process, including users and specifiers, budget holders, commercial managers and other decision makers. Recommendations designed to achieve this are set out in Chapter 6.

Lessons for SBRI

- Though use of SBRI is patchy, it is by far the most widely used mechanism to support innovative procurement by the public sector;
- Its unique features compared with other innovation policies mean it has the potential to play a powerful role in helping innovative UK start-ups and SMEs grow their businesses;
- Despite concerns that SBRI's full potential has not been achieved under either of these headings, there are big economic gains to be had from making the changes and investments necessary to make it work properly across the public sector;
- For the full potential benefits of SBRI to be realised, it must be operated as an "open innovation" process which is embedded within departments rather than a tool to be used on an ad hoc basis;
- SBRI competitions must involve all key stakeholders and decision makers throughout the process, from problem definition to operational trials;
- Major funding changes are required to bring it closer to the US model.

Chapter 5 - SME Policy Challenges and SBRI's Potential Long Term Contribution to the Industrial Strategy

Chapter Summary

- Long development times and global competition from companies and countries with significant R&D resources make commercialising research breakthroughs very challenging. Businesses undertaking sequential applications development projects for specialised lead customers play an important role in moving new technologies into the mainstream. SBRI could help SMEs turn UK technical leadership in new areas of science into commercial leadership;
- The shortage of early stage venture capital in the UK reflects very low average investor returns over three decades or more. Many successful UK STEM based companies are largely funded in their early years by customer contracts instead. By enabling the public sector to play this role, SBRI can help increase returns to UK venture capital to the point where it becomes attractive to investors;
- By reducing, or removing, the need for early stage venture capital SBRI can also make it easier for entrepreneurs who want to grow a sizeable UK company to retain control of their businesses and resist pressures for early trade sales;
- Many of the largest STEM based businesses to have been created in the UK over the last forty years were created on the back of lead customer contracts to fund product development, often in specialised or unfashionable fields. A well- managed SBRI programme could help create a new cohort of world class British science and technology based companies.

SBRI Contribution to Policy Challenges

There are three important UK industrial policy challenges which SBRI could help address:

- How to capitalise on UK strengths in science and technology research;
- Shortage of early stage venture capital;
- Loss of potential UK jobs through early acquisition of successful start-ups by foreign companies.

Examining the early history of the most successful UK STEM based companies shows how SBRI and other lead customer based policies could help address these challenges and build a new cohort of world class British companies.

Challenge Number 1: Capitalising on UK Strengths in Science and Technology

Statements to the effect that *the UK has had a strong record of scientific and technological discovery, but a weaker record in translating these discoveries into new businesses and economic success* have been repeated in different forms by successive observers for at least fifty years.

Scientific research has long thrived on global networks – through publications, conferences and now the internet. Academics and companies everywhere are on the lookout for technologies that could become strategically important. So, after Andre Geim and Konstantin Novoselov published details of a simple method for isolating single atom layers of graphene in 2004, research teams sprang up all over the world. There were nearly 26,000 patents published by 2014, increasing at a rate of 9,000 a year.⁴⁸ Samsung is the organisation with the largest number of filings. UK based organisations represent less than two per cent of graphene patents, compared with 29% for China.

The likely level of global interest, together with the long lead times involved, makes translation of an initial research breakthrough into commercial success in the UK an extremely challenging goal.

Research breakthroughs often take the form of platform technologies with multiple, but as yet untested, potential uses. Sequential product developments by businesses, aimed at applications for different customers often play a key role in this translation process. As these progress, the performance of the technology gradually improves and costs come down, so commercial applications move from niche markets to the mainstream. The history of Photobit, summarised on page 21, illustrates this process and shows how

⁴⁸ *Graphene: The worldwide patent landscape in 2015*, Intellectual Property Office, March 2015

programmes like SBIR and SBRI can provide some of the application challenges and funding to drive the commercialisation process.

Challenge Number 2: Shortage of UK Venture Capital

Successive UK Governments have rightly put much emphasis on the need for a strong, early stage venture capital industry to back new UK businesses. In 2015 venture capital constituted 6% of Private Equity investment in the UK and Ireland reported by the BVCA. Of this, just £99M (under a third) was in seed and start-up capital.⁴⁹

A separate review has recently been undertaken by the Treasury on Patient Capital. The question for this Review is the extent to which SBRI can substitute for, and complement, venture capital.

The lack of institutional investor enthusiasm for UK venture capital reflects a long period of disappointing financial performance. British Venture Capital Association figures show that venture capital, technology and early stage funds have consistently delivered returns lower than other private equity asset classes, generally regarded as lower risk, over most of the last three or four decades.⁵⁰ Whilst there is wide variation between funds around the average, institutional investors in private equity make asset class allocations largely based on average returns.

For early stage UK funds, the small size of the venture capital industry, and lack of competition, creates special problems. Unless they can follow their initial investments over several rounds they face the likelihood of being punitively diluted, through preference shares, and “pay to play” conditions often imposed by later investors. It is generally more sensible to be a second, or third round investor in the UK venture capital industry than to go first.

The lacklustre performance of venture capital as an asset class is more or less common across Europe.⁵¹

Part of the weakness of UK and European venture capital industries is due to the absence of a large homogenous market of the kind that exists in the US. This means that successful European start-ups struggle to grow as quickly as their US competitors or near equivalents, delaying the point at which they can list on a public market and raise

⁴⁹ *Private Equity and Venture Capital Report on Investment Activity 2015*, BVCA, 2016.

⁵⁰ BVCA Performance Measurement Surveys.

⁵¹ Performance data published by Invest Europe and EVCA, its predecessor.

substantial funding.⁵² As a result they have less cash than their competitors to invest in R&D, business development and acquisitions as their markets mature. It can also make them more likely to become takeover targets rather than acquirers in their own right.

Venture capital success depends on the five or ten per cent of company investments delivering spectacular returns (“home runs”). So venture fund managers must focus on industries and businesses with the potential to return typically ten times the amount of cash invested within five to seven years. They can play a powerful role in funding the rapid scale up needed.

Software and internet businesses are one of the few areas where this is possible, as development times can be relatively short and customer purchasing decisions quick and straightforward. The likelihood of success usually becomes clear within two or three years. VC’s operating in this sector usually look for investments with big market potential and strategic value to acquirers from the start.

Venture capital backing is much less suited to start-ups in a wide range of other sectors, where technology development and evaluation times are longer, markets are smaller, specialised or fragmented, and products have to be sold into complex value chains, with lengthy end-user buying cycles.

Partly as a result, the early funding of successful UK companies in these sectors often comes mainly from consulting and R&D contracts for customers. Some, like Cambridge Neurodynamics, from which Autonomy later spun out, and Cambridge Antibody Technology, failed to raise venture capital at all. Some like Dyson and Renishaw avoided it. Others, like Cambridge Silicon Radio and Domino Printing Sciences, were set up with venture capital, but only after their technology and founding teams had been assembled and tested on the back of contracts for clients of their previous employer, in this case Cambridge Consultants.⁵³

SBRI is a mechanism to enable the public sector to play a part in building these sorts of companies, both as an alternative and as a complement to venture capital. In doing so it should also make UK venture capital a more attractive asset class for institutional investors.

⁵² Sir Michael Moritz, the Welsh born partner in Sequoia Capital whose VC investments include Google, Yahoo, PayPal and YouTube made this point in an interview feature in the UK Sunday Times: *Welshman who made a killing in Silicon Valley*; Sunday Times 10th April 2011.

⁵³ *Exploding the Myths of UK Innovation Policy*, David Connell and Jocelyn Probert, Centre for Business Research, Cambridge Judge Business School, 2010

Challenge Number 3: Acquisitions by Foreign Companies

There has been much recent discussion of the number of successful R&D based companies that have been acquired by foreign companies.

It is important to distinguish between those acquired for their revenues, profits, management and employees, as opposed to those acquired at a much earlier stage of development for their technology.

Once a technology proves to be valuable, the 10-year limited partnership model typical of VC funds almost inevitably leads to the companies they control being sold before they have had a chance to develop into a fully-fledged, profitable business, with a long-term growth trajectory.

The professional managers VC's often recruit into the companies they invest in normally have this as their target. Opportunities to return cash to investors through a UK IPO are rare.

But the frequency of early trade sales by successful start-ups also reflects the much higher strategic value that breakthrough technology companies offer to large corporate acquirers compared with the returns to financial investors from growing a profitable, independent business over the longer term. This extra strategic value can come from their potential to differentiate an acquirer's existing core business from competitors and increase the value of its brand, or by providing new products and lines of business to push through its existing marketing and distribution channels.

Sometimes acquirers continue to invest locally, but all too often the result of these early technology acquisitions is the departure of the entrepreneurial management team that drove early success, loss of strategic control to the acquirer's head office team, and truncation of further growth in the UK.

Globalisation, together with the open nature of the UK market, ease with which British companies can be acquired and the fact that English is the international language of business, means most acquirers are inevitably based overseas.

In this respect the VC industry plays a different economic role in the UK than in the US where the pure size of its industrial base means acquisitions are most likely to be by US companies, so the side effects of early trade sales are of less concern.

For many innovative companies, a trade sale to a larger company is the best way forward. And not all entrepreneurs wish to grow a substantial business. But there are strong arguments for policies that can help those that wish to do so, to get their business

established in a way which leaves them in control of their destiny, by avoiding or reducing the need for early stage venture capital.

SBRI could offer part of the solution.

Lessons from History: Strategies Pursued by Successful UK STEM Based Companies

Science and technology companies start in many different ways. A great deal of publicity is focused on university spin outs, particularly those based on research breakthroughs. In fact, there is a good deal of evidence to suggest that while alumni from research universities play a vital role in creating new STEM based businesses, only a small proportion of their start-ups are based on IP they have developed there.⁵⁴ Whilst there are, of course, exceptions, businesses started by career academics rarely go on to become major corporations. The potential size of their markets may enable them to interest venture capital investors, who will often help them build a management team. But technologies are often at a very early stage, so success rates are low and usually lead to a trade sale.

For entrepreneurially minded students, graduates and young post-docs, the situation is perhaps rather different. Herman Hauser (co-founder of Acorn computers, ARM, Amadeus Capital and other companies), Mike Lynch (Cambridge Neurodynamics, Autonomy and Darktrace), Bill Gates (Microsoft), Larry Page (Google) and Mark Zuckerberg (Facebook), are some well-known examples. For such individuals, retaining control and growing a sizeable business over the long term is often a much more attractive option than making an early trade sale. In some cases they start their businesses with expertise and ambition, rather than a clear product idea.

⁵⁴ Data included in a definitive study of the entrepreneurial impact of Massachusetts Institute of Technology alumni indicated that only 10% of ideas for their firms came from research, with over two-thirds coming from industry work experience. *Entrepreneurial Impact: The Role of MIT*; Ed. Roberts and Charles Eesley, MIT School of Management; Kauffman Foundation, 2009.

Robert L. Byer, a distinguished Professor of Applied Physics at Stanford University and serial photonics entrepreneur, has come to a similar conclusion. Based on an analysis of 1000 companies “*spun-out*” of the university he found that only 5% used technology derived from it. He ascribes the importance attached to the contribution of Stanford University technology to Silicon Valley as “a myth”. “Probably the single most important contribution Stanford University has made to the development of Silicon Valley is to attract and educate talented students, many of which elected to remain in the Bay Area.” *Silicon Valley Goes Global*, Presentation by Robert L. Byer at SPIE Innovation Summit, San Francisco, 2008.

A report on successful companies in the Cambridge cluster came to a similar conclusion; (*Exploding the Myths of UK Innovation Policy*, *op.cit.*).

Many other new STEM based businesses are created by people who have already worked in industry. The rights to any ideas developed previously may belong to past employers.

Whatever their background, entrepreneurial scientists and engineers therefore often adopt a “soft start” business model, so called because it is built around early sales of consultancy and technology development contracts, rather than the well-defined product concepts on which “hard start-ups” are based. Over time this can lead to opportunities to take on bigger and more demanding projects, increase the team, take advantage of other business opportunities as they become apparent, and ultimately to create proprietary technology products.

The Cambridge consultancies illustrate the power of this model as an engine of economic growth. Cambridge Consultants, the first of these, was established in 1960 by three Cambridge University engineering graduates. There are now some 2,000 scientists and engineers working in the Cambridge consulting sector, developing STEM based products for companies across a wide range of industries, and typically earning over 60% of their revenues from exports. Along the way they have spun off a series of successful product businesses in digital printing technology, semi-conductors, telecommunications equipment, pharmaceuticals research and manufacturing equipment, and security technology. Many of these companies include UK manufacturing operations and together they employ several thousand people.⁵⁵

There are other, less obvious UK examples of this process. Vodafone, the most successful UK start-up since the Second World War, is essentially a spin out from Racal, which started as a specialist two-man radio consultancy to the MoD in 1950.

And the role played by development contracts in creating product businesses is not limited to the UK.

Microsoft’s breakthrough came in 1980, five years after it was founded, after it won a contract to develop the operating system for the new IBM PC. IBM gave Microsoft the rights to sell the operating system to other companies, thus creating the PC clone industry. Microsoft IPO’d in 1986, but had never needed to raise venture capital.⁵⁶

And though Intel was venture capital backed from the start, the single chip processor on which its success is based was funded by Busicom, a Japanese calculator company. In 1971, Busicom agreed to share the rights with Intel in exchange for a reduced R&D bill,

⁵⁵ *Exploding the Myths of UK Innovation Policy*, op.cit. and *The Cambridge Phenomenon*, Kate Kirk and Charles Cotton, Third Millennium Publishing 2012.

⁵⁶ *The Rise of DOS: How Microsoft Got the IBM PC OS Contract*, Michael. J. Miller, PC Magazine, August 10, 2011.

giving Intel the opportunity to sell its design to other customers and further develop the technology.⁵⁷

By providing customer funding, along with intellectual property rights, SBRI provides a way to participate in, and accelerate, this process, especially for smaller specialist businesses with a consulting model.

Building a British Mittelstand

Policymakers outside Germany often look with envy at the German Mittelstand, a term originally used to describe German companies with less than 500 employees, but now generally taken to include companies that retain the Mittelstand philosophy, but have grown larger. These companies are sometimes described as the “engine of the German economy”.

Mittelstand industrial companies are typically family owned. They have high levels of innovation and a long-term approach to business. According to the German Federal government, “They include 1300 world market leaders that have successfully found niches for their products”.⁵⁸

The ownership and governance structures of many of Germany’s companies arguably make it easier for them to adopt a long-term approach to innovation than most large UK companies. But it is useful to examine the histories of UK companies that have achieved similar success in terms of growth, exports, longevity and commitment to innovation.

Examination of nine such companies, Dyson, ARM Holdings, Renishaw, Oxford Instruments, Domino Printing Sciences, Cambridge Silicon Radio, Autonomy, Cambridge Antibody Technology and AVEVA, offers a number of important lessons for the Industrial Strategy:

- Lead customers have, in different guises, played a key role in originating and funding the development of their products;
- Many started in specialised or unfashionable fields where there was little venture capital or government interest;

⁵⁷ *The Microprocessor Turns 40: Intel’s Monumental Accident*, Michael Kanellos, Forbes Magazine, November 15th 2011.

⁵⁸ *German Mittelstand: Engine of the German Economy*, Federal Ministry of Economics and Technology

- Many either raised no venture capital investment or delayed it until growth was underway; in two cases founders and their families still have controlling shareholdings;
- Growth has taken place over a long period rather than in spectacular bursts.⁵⁹

Though some have recently been acquired, this is after many years of operating as successful businesses. The SBRI programme could play an important role in helping other UK companies with this potential to become established.

Lessons for SBRI

Lead customer, and other R&D contracts, have played a major role in creating successful UK based and controlled companies.

There are big gains to be had from the UK public sector playing a fuller role in this process, and SBRI can help achieve this.

⁵⁹ Details at <http://www.davidconnell.org/uk-mittelstand-companies.pdf>

Chapter 6 – Conclusions and Recommendations

Strengths and Weaknesses of SBRI Today

At its best SBRI has:

- provided highly innovative and potentially cost effective solutions to public sector challenges (like PolyPhotonix in the treatment of diabetes related blindness and Ancon Technologies in airport security);
- provided a phased mechanism for managing major policy challenge programmes, like wave energy in Scotland and vaccines for global epidemics (ODA/DoH);
- funded the development of specialist technologies, like biomass energy generation, to meet departmental objectives for which commercial funding is not readily available;
- led to the creation of new companies like Owlstone Medical and RepKnight that have gone on to raise significant funding;
- enabled existing start-ups like Fuel3D not just to sell into the UK public sector, but through the credibility gained, to raise finance to successfully commercialise its technology in other applications globally;
- made it possible for established SMEs, like Global ASV, to develop products for applications outside its existing customer base.

But there is also a long tail of SBRI projects that have been awarded contracts that are too small to make much of an impact. Average SBRI contract values have been significantly below the US SBIR, and UK departments with average Phase 2 contracts less than the much lower, minimum SBRI guideline accounted for 84% of SBRI projects. Partly as a result of this, the number of finished products procured by government has so far been quite small.

The final operational testing and adoption stages of the SBRI process remain problematic across many departments. In some cases, such as the NHS, making sales is complicated by a complex, impenetrable and geographically dispersed approvals and commissioning process.

Spending departments and agencies regard it as BEIS's job to support business R&D, not theirs. And pressure on departmental budgets means that any spending on innovation is often focused on achieving short term imperatives. Stimulating the development of UK SME's is not a priority, even if there are potential long term cost savings. In terms of SBRI therefore, the congruence between spending department objectives and those of the Industrial Strategy is only partial.

Pressure on departments to run SBRI competitions from the Treasury and Cabinet Office has succeeded in increasing the use of SBRI across government. The work done by the Innovate UK team with spending departments has played a key role in achieving this. However, overall spending is still far below the desired level. The competitions taken forward have often been selected on an ad hoc basis, with themes suggested by senior officials rather than in any systematic way, and with programme management teams sometimes lacking appropriate skills. Departmental funding has often declined again once the pressure has come off. One high level intervention resulted in 23 new SBRI competitions being planned by departments working with Innovate UK. Later the same year, budget cuts led to 80% of these being withdrawn. Only a handful of departments have embedded SBRI programmes, operating in a systematic manner to identify key challenges and progress possible solutions over a period of years.

Altogether, the experience of SBRI over the last 7 years indicates that a different approach to funding and managing it is needed if the full potential benefits are to be derived – by the public sector, by businesses and by the economy at large.

What a Well Managed SBRI Could Offer the UK

From the point of view of the public sector SBRI:

- Offers a way to gain access to new technologies, products and solutions to help to improve cost effectiveness and address policy challenges;
- Provides a staged, risk managed approach to innovation, in line with best practice “open innovation” approaches from the private sector;
- Could encourage and assist the development of a longer term, and more strategic, approach to procurement more generally that factors in the potential for innovation in a systematic manner;
- Offers a way of doing so that supports the Government's goal of increased SME participation in the £265 billion public sector procurement market, particularly amongst STEM based companies with the potential to generate high value jobs, and significant export earnings.

From the point of view of businesses, SBRI:

- funds product developments that are focused on real customer needs;
- provides credibility to attract further customers, partners and investment, thereby speeding time to market and reducing the width and depth of the valley of death;
- provides 100% funding for product development and testing in amounts sufficient to have a transformational impact on company development at a point when other sources of funding may be unavailable or insufficient;
- can take companies to the point where they are “VC ready”, increasing the viability, and hence availability, of UK venture capital;
- can make it easier for those entrepreneurs who wish to do so, to retain independence and build a substantial UK based business;
- can provide a cost-effective way to help companies in very specialised or unfashionable markets get started;
- provides market pull to complement the more technology push elements of many other innovation policies.

Key Areas Where Change is Required

There are six challenges that need to be addressed to deliver SBRI’s full potential:

- It must be financed and organised in a way that encourages and rewards participation across government, and is seen as an opportunity rather than a tax;
- It needs enduring, high level ownership within government. SBRI is effectively an orphan policy;
- Budgets – an effective SBRI programme requires predictable, three to five year rolling budgets over several years, adequate to do the job, and in a form that enables two year Phase 2 contracts to be awarded to companies;
- SBRI contracts must be large enough to enable companies to get to key milestones likely to lead on to procurement and commercialisation;
- Programmes must incorporate a way of bridging the disconnect that inevitably exists between *pre-commercial procurement* to fund product development, and the

customising, testing, and trial deployments required before *commercial procurement* can take place;

- SBRI programmes must be embedded within the spending departments and agencies running them, and run by stable teams that include the appropriate strategic and technology programme management skills as well as the right connections across the sponsoring organisation.

Budgets and High Level Ownership

SBRI budgets are currently entirely the responsibility of spending departments and agencies. This is in stark contrast to the US SBRI where they are defined by law. This is a key feature of the US programme and underpins its continuity and effectiveness.

There are four ways in which this could be achieved in the UK:

1. By continued encouragement and pressure on departments to allocate SBRI budgets.

The evidence over many years shows that this is very unlikely to work.

2. By ring-fencing a component of departmental budgets for SBRI.

In the US this is achieved through legislation. This would represent a major precedent if tried in the UK and is unlikely to be acceptable. The alternative would be by Treasury diktat, though this would not provide long term security of funding. Furthermore, there is no magic formula for deciding how much a department or agency should spend on SBRI.

3. By transferring funding responsibility for SBRI fully to Innovate UK.

Such an approach would undermine ownership of the programme by customers and specifiers, one of the key features of SBRI.

4. By creation of a central fund with a rolling 5-year budget, renewed and rolled forward each year, into which departments or agencies can bid to run SBRI programmes.

Both the Government of Northern Ireland and the Welsh Administration have adopted this kind of approach. In each case it has led to a variety of bids from across departments, led by enthusiastic champions.

A central fund would enable any government department or agency to come forward with programme ideas and it would change the motivation to run SBRI programmes from stick to carrot. It also provides a way of addressing other key challenges. It is the approach recommended by this Review.

Recommendation 1 - A New Central SBRI Fund

- A central fund should be established with a rolling 5-year budget profile into which teams from public sector organisations can bid to fund a programme of SBRI competitions;
- The central SBRI programme budget should be set for five years into the future, and renewed annually, permitting funding of SBRI competitions on a planned basis from problem definition to completion of the final phase of funding;
- Government should plan for the annual value of SBRI contracts awarded by spending departments to grow to around £250m per annum over six years. Assuming well established SBRI programmes continue to be funded directly by departments at roughly current rates, this equates to central fund expenditure growing to £120m by 2020/21 and £200m by 2023/24;
- Initial allocations to a limited number of well managed programmes with budgetary or funding model restrictions could begin in 2017/8 providing strong proposals are put forward;
- Central funding should include a small element for department or agency programme management costs where appropriate.

Any UK or English spending department or agency should be able to bid for SBRI funds. Often it will be the operational agencies directly responsible for managing spending that are best placed to use SBRI, rather than the departments to which they are responsible. Bids should in general be for four year programmes, covering a portfolio of competition topics, and with a single management team responsible for delivering them to ensure continuity. Teams would need to rebid each year to roll forward the four year funding envelope.

There should be a facility for smaller agencies to bid for funding for single competitions, possibly with external competition management support from IUK or other specialist organisations. However, programme ownership and responsibility must rest firmly with the agency.

The Devolved Administrations have their own budgets and innovation policies. They should be encouraged to collaborate with programmes funded through the central fund, through cost sharing and other mechanisms. There are important economies of scale to be gained in this way.

I propose that the central fund is named the *Tommy Flowers Fund*, after the British creator of Colossus, the world's first programmable electronic computer to help read German army messages encrypted using the Lorenz cipher in the latter stages of the second world war.

Recommendation 2 - National SBRI Fund Board

The fund should be overseen by a small National SBRI Board reporting to the Cabinet Office and comprising officials bringing commercial, innovation and operational perspectives from the public sector, including Innovate UK, together with individuals from the private sector with business and venture finance expertise.

Its responsibilities should include:

- Setting funding conditions and guidelines for four year funded departmental and agency SBRI programmes to ensure conformity with objectives and best practice;
- Reviewing and approving departmental or agency programme proposals, including the approach and expertise proposed for programme management;
- Monitoring SBRI programme progress and performance;
- Publishing an annual report;
- Delivering cross-programme support measures like conferences, training, etc;
- An annual awards ceremony similar to that run by the US SBIR that recognises the achievements of programme management teams and SBIR beneficiaries.

It has sometimes been suggested that central funding should always require departmental contributions. Past experience suggests that this would prevent some good SBRI programme proposals coming forward and I have therefore rejected this idea. Departmental support is best deployed, as in the US SBIR, to contribute to Phase 3 work and trials of the best SBRI funded projects leading on to commercial procurement. This is the point at which real commitment to deployment is required. By providing 100% funding, central SBRI funding enables projects to get to this stage.

A small team of senior individuals with extensive private sector innovation programme management experience should be recruited to deliver these responsibilities and help develop this expertise in departments.

Phase 1 and Phase 2 Funding Guidelines

A key objective of SBRI is to provide funding contracts that are sufficient to take projects to a major development milestone of relevance to the customer/specifier and to potential corporate partners and investors.

Recommendation 3 - Phase 1 and Phase 2 Funding Guidelines

- SBRI contracts financed through the central fund must be sufficient to take projects to a meaningful milestone. The amounts required will depend on the task. But in general the original guidelines for Phase 1 and Phase 2 contracts (£50-£100k, and £250k-£1m respectively) should be closely adhered to;
- Most Phase 2s should be expected to be at the top end of the range;
- The percentage of projects graduating from Phase 1 to Phase 2 should be broadly in line with the US SBIR norm of 40 to 50%, providing they are of sufficient quality;
- Phased payments, including an upfront element, should be adopted to make the programme as SME friendly as possible.

A New Phase 3 for Operational Evaluations and Pilot Procurements

The review identified a number of situations in which there was a need for government funding to cover work beyond Phase 2. Examples include:

- Trial deployments and testing of products in NHS operational environments like GP's and hospitals, and assembly of information on costs and outcome benefits to build a case for purchasing across the NHS, often complicated because costs and benefits accrue to different budget holders;

- Expensive capital equipment trials like the BEIS biomass to energy demonstrator projects or Northern Ireland’s chicken litter disposal projects;
- Customisation, integration and testing to insert products into existing systems or turnkey projects, for example, in defence and transport.⁶⁰

Recommendation 4 - Selective New Phase 3 Contracts for Evaluations and Trial Deployments

SBRI programme bids should include an element for Phase 3 funding where appropriate. However, contracts should be awarded very selectively, and only when the viability of the technology has already been well demonstrated and there is strong interest in an operational scale evaluation by prospective customers.

The form of Phase 3 project funding should not be limited to 100% contracts. Programme managers should be able to consider other elements in the funding package, including mechanisms to provide a potential return on the government investment. One possibly mechanism is through equity investment options. This is a model similar to that used by In-Q-Tel, the CIA’s very successful security technology fund.

Phase 3 contracts should only be awarded to companies that have demonstrated that with this and other sources of finance they are likely to be able to take the project forward to commercialisation. The two year Phase 2 funding provides a runway for companies to raise money or find partners if needed.

It is important that this extra level of funding does not encourage dependency.

Most innovative product developments, even those linked to well defined customer needs, end up by being commercially unsuccessful. And the long lead times often associated with product development and testing, mean that the date at which a product is ready to sell will rarely coincide with the date at which the intended customer is ready to purchase. Budget holders and influencers may have changed in the meantime, as may have priorities, and purchase criteria. Other companies may have developed products that are more cost effective or offer a completely different approach to the problem. Many SBRI funded innovations will need to be implemented through prime or first tier contractors or through system integrators, who will have their own priorities, views and processes.

⁶⁰ See Appendix 1

These situations are common to both public and private sector markets.

It is important that companies do not see the agency that awarded it an SBRI contract as the only customer or source of funding, or rely on it to deliver orders for the resulting product at a time of the company's choosing.

As in any new business it is up to a company's Chief Executive to work out how commercial buying decisions are made and who they need to make contact with. Government can help navigate these processes, but it cannot be expected to replace the key role of the entrepreneur, which is to find the revenues and investment needed to make a success of his or her business.

Improving Procurement Outcomes and Commercialisation

To transform the public sectors' approach to innovation, and take advantage of the mandate provided by central funding, SBRI must be embedded within departments and managed using systematic, open innovation processes similar to those illustrated in Exhibit 8 in Chapter 4. They include challenge identification and definition, monitoring and evaluating individual projects and selecting those offering the best potential outcomes for further funding at each phase. SBRI programme managers must ensure that end users, budget holders and other decision makers are fully engaged in the whole SBRI process through to operational trials.

For SBRI competitions aimed at public sector operational challenges, a key objective is to strengthen the demand pull from public sector sponsors, to ensure needs are defined in a way that can lead to commercial procurement for successful projects and that testing and approval processes are properly understood. Where appropriate, the new EU Innovation Partnership rules should be used, as an adjunct to the existing SBRI process, to smooth the transition from testing to commercial procurement. Where the eventual product will, if successful, need to be incorporated into a complex value chain, for example in defence, support should be sought from individuals who work, or have worked for, prime or first tier contractors.

For SBRI competitions aimed at developing products to meet policy objectives, and which will not be bought directly by the sponsoring organisation, a similar level of engagement with specifiers and potential purchasers is also required.

Competitions should be focused as much as possible on topics where UK SMEs and new ventures in large companies potentially have important contributions to make.

Recommendation 5 - Embedding Best Practice Innovation Programme Management within Departments

The National SBRI Board should ensure that the SBRI programmes it funds are fully embedded within departments and operated in a systematic manner as described in Chapter 4. They must be directed, managed and supported in a way that maximises the probability of commercial procurement and commercialisation of successful developments.

Key aspects include:

- Small Programme Boards established for each major programme, drawing on business and or VC experience to steer, oversee and support management teams. This should include supply chain experience where products are not bought directly by the public sector;
- SBRI programme management teams that include people with both technology programme management expertise and knowledge of the department or agency's operations. It will often be necessary to recruit from outside government;
- A systematic approach to challenge selection and definition, covering different aspects of a sponsoring department or agency's responsibilities through a rolling programme of competition topics;
- SBRI competition management approaches involving challenge owners, potential users, budget holders and other key decision makers, including where appropriate prime contractors, throughout the SBRI process, from problem definition to evaluation and operational trials;
- Face to face interviews with shortlisted applicants by panels including participants with technical, procurement and business perspectives;
- Innovation programme management training for those engaged in SBRI competitions.

For smaller programmes, it may sometimes be appropriate to outsource detailed aspects of competition management and project reviews to Innovate UK or other organisations. But the sponsoring department or agency must always demonstrate strong ownership and be actively involved in the whole process.

Monitoring and Evaluation

Evaluating the effectiveness of government innovation policies is always difficult. It can take many years for investment in R&D to produce a marketable product and obtain the approvals and achieve the design-ins or listings to begin to generate sales.

In the case of SBRI monitoring is made even more difficult as spending departments currently have no obligation to share data with Innovate UK.

Recommendation 6 - Transparency, Monitoring and Evaluations

All SBRI programmes receiving central funding should be required:

- to provide details of awards, including recipients, contract amounts and summary project details through a publicly searchable database similar to SBIR's TECH-Net;
- to include future monitoring information obligations in SBRI contracts with companies;

Ongoing monitoring should be complemented by more comprehensive reports at five yearly intervals starting in 2022. Evaluations should focus on real, leading event-based indicators of progress, as well as quantitative measures.

SBRI programme managers will need to reapply annually for rolling four or five year funding to launch new competitions. This reapplication process provides a mechanism for the SBRI Board and management team to assess the extent to which each programme is achieving its objectives and to adjust the allocation between programmes and rate of expansion of SBRI as a whole. Initially this assessment will be on how well the programme is managed, but over time, it can be extended to cover the potential impact and progress of projects, and the companies undertaking them.

Branding

The Small Business Research Initiative is now an established brand, though under EU regulations at least, it is not exclusively reserved for small businesses. And it is about product development and trialling not research. Whether it should be rebranded, and if so how, should be considered prior to launching the central fund.

Departments and Agencies Offering Opportunities for New and Improved SBRI Programmes

There are opportunities for SBRI to be deployed across the public sector. Smaller specialist agencies, may often offer better opportunities than some of the larger spending departments. Ultimately it will be up to each one to decide if SBRI could work for them and make proposals to the central fund.

Observations on some individual departments and agencies where SBRI could play a useful role, or achieve greater impact, are included below.

Defence

In practice, the MOD expects most innovations to be provided by prime contractors and other established defence suppliers, either by sourcing components and subsystem technologies on international markets or by funding R&D themselves.

It has decided that it is in its best interests to spread its limited Dstl SBRI R&D funding over a wide range of early stage research and demonstrator projects, taking them to about TRL 4 or a little higher, together with the occasional later stage development project for urgent requirements or needs specific to the UK. The Defence Innovation Initiative and Defence and Security Accelerator announced in 2016 are not expected to change this picture materially.

However, there are major benefits to be generated for UK SMEs and the wider economy from the MOD playing a fuller role in funding the best projects.

In this respect the objectives of the MOD and the Industrial Strategy are, for very understandable reasons, not completely aligned. The Home Office is in a similar position.

Top up funding to increase the number of MOD and Home Office Phase 2 and Phase 3 projects, and provide contracts large enough for firms to make real progress, could pay dividends for the UK's STEM based start-ups and SMEs. Dstl could play a stronger role in introducing SBRI funded UK companies to US Department of Defense funding sources.

NHS England and Department of Health

The NHS England SBRI is probably the best role model for other SBRI programmes. However, the key innovation challenge is perceived, correctly, by senior members of NHS management to be the adoption and spread of existing innovations irrespective of where they come from, rather than funding the development of new ones. Once again departmental objectives are not completely congruent with those of the Industrial Strategy.

A larger NHS England SBRI budget, facilitated through a central fund could address this problem. Better collaboration with the Department of Health's National Institute of Health Research to fund clinical trials of SBRI funded developments would assist progress through to NHS procurement.

There is also scope for a more systematic DoH SBRI programme in the biotechnology and genomics arena, particularly in fields where private sector investment interest is weak, like antibiotics, vaccines and research tools. Past competitions have been on an occasional, ad hoc basis.

Innovate UK

Innovate UK has found the SBRI a useful mechanism for some of its own core programmes. It is to be hoped that it will continue to do this from its own funding. The central fund is aimed at spending departments and agencies with procurement budgets and policy responsibilities. Innovate UK may well, as now, wish to collaborate with other areas of the public sector where there are common interests. Though it is unlikely that it will be able to draw on the central fund directly.

It should be encouraged to explore new ways of encouraging private sector organisations to act as lead customers for SME innovations. The precedent created by the EU SME Instrument suggests that a competitive grant programme to fund product developments in SMEs alongside lead customer funding could be an effective way of achieving this.

Research Councils

Rather like defence, research tools often provide a first application for new technologies. Oxford Instruments and Solexa are examples. Academics in British universities could provide lead customers for new STEM based businesses serving the research market. There is a strong case for the Research Councils to take a lead in using SBRI to stimulate

this process in a more systematic way. Not only could this help create new products, it could also increase the chances of major breakthrough technologies, like Solexa's, being fully commercialised by UK based companies.

Local Authorities

There are many aspects of local government responsibilities for which SBRI could create solutions offering increased cost effectiveness. These range from urban transport and road maintenance to adult social care.

The fund should be open to proposals to run SBRI competitions from the larger metropolitan authorities and organisations acting on behalf of wider local authority groupings where there is a clear lead customer for successful innovations.

Infrastructure

Major infrastructure programmes, like high speed rail, urban transport systems, airport investments and telecommunications and utilities projects, present important opportunities for deploying SBRI. The long lead times associated with these projects could enable innovative technologies to be developed, tested and designed into supply chains, and the national SBRI team should encourage the creation of SBRI programmes linked to them.

Digital

Government is massively dependent on digital technologies to run mainstream operations and deliver services to the public. New systems are often developed through turnkey projects by system suppliers and there is a long history of overruns. The SBRI methodology could offer a means to address key challenges and reduce implementation risks before commissioning turnkey system implementations.

The BBC

The BBC's 1981 contract with Acorn to supply home computers for the BBC Computer Literacy Project underpinned the creation of a whole cohort of UK technology companies, including Arm Holdings.⁶¹

The BBC's 250 man R&D Department has played a key role in the development of broadcasting technology and new standards and it is now leading international efforts to transform traditional broadcasting into an IP based ecosystem. It should be invited to submit a proposal for funding to run an SBRI programme linked to its own procurement needs.

⁶¹ *Exploding the Myths of UK Innovation Policy*, op.cit.

Appendix 1 – How Different Departments and Agencies have used SBRI

Between October 2008 and October 2016, 325 SBRI competitions were run by some 22 different sponsoring bodies. They range from large departments like MOD and the NHS to smaller organisation like the Food Standards Agency and UK Space Agency, and to specialised organisations like NC3Rs, whose aim is to replace, refine and reduce the use of animals in research and testing.

A selection of SBRI programmes are summarised below. Some departments have run SBRI competitions regularly each year, others have run them intermittently, with spending levels varying widely from year to year. Average contract sizes, and the proportion of Phase 1 contracts leading on to Phase 2s also vary widely between departments. The overall level of SBRI funding increased after around 2011/12 as departments became more familiar with the concepts and Treasury targets were put in place.

In order to provide a simple, consistent, and representative way of positioning each department's approach, each section begins with data on the average number of SBRI competitions run per annum and other key departmental metrics, based on the four most recent full years of SBRI data.⁶²

⁶² These metrics were derived from total SBRI competitions launched during 2012/13-2015/16 and associated contract numbers and value by phase in the Innovate UK SBRI database. The inclusion of competitions is determined by their opening month, and the numbers of contracts and value associated with these competitions are grouped by the relevant competition's opening month. They exclude three partially European Commission funded pre-commercial procurement competitions, one Phase 3 SBRI competition and one unclassified competition. The number of projects is estimated as the sum of Phase 1 contracts and Phase 2 only contracts.

NHS England

SBRI Programme Metrics (Annual Averages 2012/13 to 2015/16)

Competitions: 6; Total Value of Contracts: £12.7m; Number of Projects Funded: 27

Phase 1 Value: £94k; Phase 2 Value: £849k;

Phase 2s as a Percentage of Phase 1s: 44%

Programme Management

The NHS England SBRI programme is the closest to the US SBRI model, and, with its predecessors has been running continuously for longest. It is now branded as SBRI Healthcare. The programme is led and managed by the team that previously created and managed the pioneering NHS East programme in 2009.

NHS England is one of the few bodies to run regular SBRI competitions on a systematic basis and operates a rolling, long term programme. It has a dedicated team, led by Karen Livingstone, National NHS England SBRI Director and a Director at the Eastern Academic Science Network.

The Programme has a Management Board with an independent Chairman, and membership drawn from the fifteen NHS regional Academic Health Science Networks and industry.⁶³ Its role is to provide strategic direction, oversight and support.

Detailed competition management is subcontracted to Health Enterprise East, a not-for-profit medical technology transfer organisation which spun out of the NHS in 2004. This brings together financial, IP, technical and healthcare expertise to assess and monitor projects. Individual competition themes are worked up with top specialists in the field, including both clinical and nursing staff from the AHSNs. These are expected to help

⁶³ The AHSNs are small organisations set up by NHS England in 2013 as catalysts to facilitate change across whole health and social care economies, with a clear focus on improving outcomes for patients, especially by identifying and spreading health innovation at pace and scale. They were created in response to a recommendation in Sir David Nicholson's report, *Innovation, Health and Wealth*, in 2011 and were seen as contributing to both improved patient outcomes and economic growth. However, this latter objective seems to have been downplayed in recent policy statements.

award winners engage with the NHS as companies progress their products through to clinical trials.

Consultants from the Innovate UK Knowledge Transfer Network have been used to help develop the methodology for defining detailed challenges within broad themes by analysing NHS costs and clinical pathways, and by identifying diagnostic, treatment and longer term care challenges. A “what if” analysis is then used to identify the cost and clinical benefits that might arise from innovations delivering various functional improvements. These can come from direct procurement savings, resource efficiencies, task deskilling, pathway time savings, earlier diagnostics, faster patient recovery etc.

Applications are reviewed by technical and clinical assessors and a short-list is invited for a half hour interview. Interview panels include relevant medical specialists, NHS commissioners and individuals with business, technology and venture capital backgrounds.

The interviews focus on key risks and uncertainties in the proposal, including the applicant’s understanding of clinical need, NHS procurement considerations and the commitment and ability of the team to bring the resulting product to market. These issues are examined in more detail at the longer Phase 2 interview, based on what the applicant has been able to achieve in Phase 1.

Companies are monitored closely through face to face meetings or conference calls every three months throughout Phases 1 and 2. SBRI Healthcare contract terms include a requirement for firms to provide follow up data for 3 years after completion of the project.

The AHSNs and SBRI team try to help individual award winners navigate the NHS procurement process and maximise the chances of promising products gaining early orders. All SBRI awardees are given free specialised consultancy on developing their health economics case.

The SBRI Healthcare team has an active communications programme, with its own website: www.sbrihealthcare.co.uk, an annual report and participation in industry conferences and exhibitions.

Competitions and Impact

Examples of SBRI Healthcare competition themes include:

- Improving the care of the diabetic foot ulcer – better prevention, diagnosis and treatment;
- Improving the efficiency and experience of outpatient services through better remote management of health and wellbeing;

- Child and maternal health – delivering safe, high quality, cost effective child and maternal health care;
- The GP of the Future – workload and demand management, diagnostics and earlier triage, self-care.

CASE STUDY 6: Examples of Companies Receiving NHS England SBRI Contracts

PolyPhotonix

PolyPhotonix is a company based in the North East and closely associated with Innovate UK's Centre for Process Innovation in Sedgefield, part of the High Value Manufacturing Catapult. It has developed a revolutionary, non-invasive treatment for Diabetic Retinopathy and Age Related Macular Degeneration, the two most common causes of blindness in the western world. PolyPhotonix' product, the Noctura 400, works by delivering low intensity, tuned light therapy through a sleep mask in patients' homes.

PolyPhotonix was awarded a Phase 1 SBRI contract of £100k in 2012 followed by a Phase 2 award of £359K. It also received one of NHS England's pilot Phase 3 contracts worth £1m. This enabled the company to develop the mask and related electronics, and carry out patient acceptance and usability tests together with a small-scale clinical study on patients with severe diabetes in the Czech Republic. A number of NHS hospitals are planning to start using Noctura 400 during 2017, following the expected completion of further UK clinical trials. FDA approval is also expected at the end of 2017. NHS commissioned reports show that the treatment has the potential to save the NHS in excess of £500m a year. Noctura 400 is already available through selected opticians in the UK and hospitals overseas.

ADI

ADI is a small technology consultancy based in West Yorkshire. It worked closely with Dr Frances Cole, a pain rehabilitation specialist, and other specialists in the field to develop a smartphone app – PainSense - to help sufferers of persistent pain manage it more effectively. ADI received Phase 1 and Phase 2 SBRI contracts to fund the development, totalling £886k.

The app makes use of cognitive behavioural therapy approaches developed by Dr Cole and her colleagues and allows these to be made available to a wider group of patients than would be possible through face to face appointments. An estimated 5.3 million people in England suffer from chronic pain. It has a major impact on sufferers' lives, with 24% being diagnosed with depression and 26% reporting an impact on employment.

PainSense provides better care with fewer acute hospital admissions. Potential savings to the NHS are independently estimated at £20m per annum, and it is already offered to patients through the NHS in parts of the UK.

A second ADI product, MyPathway, which provides a secure digital communications channel between patients and clinicians, has already won initial contracts with NHS and commercial providers.

Fuel 3D

Fuel 3D was founded in 2006 as Eykona, an Oxford University spin out. The company had developed a prototype 3-D imaging technology for diabetic wound management. SBRI contracts totalling £1.2m enabled this to be modified to meet the needs of specialist clinicians and trialled within the NHS. The Eykona Wound Measurement System is now in use in over 25 NHS Trusts, as well as in universities and research projects in the UK, Europe and Australia. Fuel 3D has gone on to leverage its platform to develop a suite of 3-D imaging products for a wide range of non-health markets. This has enabled it to grow rapidly and secure significant investment, including funding from In-Q-Tel, the CIA's venture fund and a €1.7m EU SME Instrument grant.

Budgets and Other Programme Challenges

The NHS England funded SBRI is one of the few SBRI programmes with a defined annual budget. However, as a result of financial pressures on the NHS this has been cut by 40% since 2014/15. A shift to annual cash budgeting has also restricted its ability to award two-year Phase 2s.

The NHS presents long standing and widely known challenges for companies trying to sell it innovative products. Giving evidence to the House of Commons Science and Technology Committee in 2012, Dr Andy Richards, one of the UK's leading bioscience and healthcare technology angel investors, said "any business plan, business model or business idea that says, 'the first thing we are going to do is sell into the NHS', just makes it uninvestable".

The problem reflects lengthy approval cycles, complex and fragmented procurement processes and multiple local commissioner budgets. Budget holders incurring the costs of introducing innovative healthcare solutions are often different to those deriving the benefits, either within the NHS, or as between the NHS and local authority adult social care budgets.

Extracts from the Association of British Healthcare Industries Response to the Industrial Strategy Green Paper

MedTech is an engineering based industry, characterised by rapid, often iterative product design and development, and a large number of small and medium sized enterprises (SMEs). It employs 93,600 people in 2,477 companies, mostly small and medium sized enterprises (SMEs), with a combined turnover of £17.1 billion.

ABHI suggests that the current balance of research funding use, between NHS, academia and industry, is at present heavily tilted to the NHS-academic axis, even with the relatively recent emphasis through Innovate UK on 'applied'. We believe that there would be a real benefit in focussing resources on the spread of innovation such as in the highly promising, but as yet not fully realised, Phase Three of the Small Business Research Initiative.

Barriers to the growth of British MedTech small and medium sized enterprises (SMEs) include difficulties in commercialisation and early stage dissemination. The Small Business Research Initiative (Healthcare SBRI) has addressed this, but has been limited by the financial capacity to progress as fully as the potential indicates. Enhanced funding for this channel could make a significant difference to fulfilment of that potential.

Multinational or small, MedTech companies effectively have only one customer in the UK, the NHS. The NHS is the biggest single payer health system in the world. This gives the UK the potential to become the best place in the world to develop, launch and assess the value of innovative medical technology. And this, in turn, becomes a significant engine for economic growth.

The NHS must provide a local market that is receptive to, and values innovation. There should be a specifically tailored programme to support the growth of British MedTech SMEs, including a focus on commercialisation and early stage dissemination, building on the rich experience from the Healthcare programme of the Small Business Research Initiative.

In 2014 some Phase 3 SBRI contracts were awarded on a trial basis. These were aimed at helping companies with the most promising projects to undertake clinical and pathway validation, making it easier to secure early sales to NHS commissioners. Eight companies received Phase 3 contracts of between £600k and £1m. Reductions in the NHS England SBRI budget have meant it has not been possible to award any Phase 3 contracts since.

More recently the issue has been addressed in the final report of the Accelerated Access Review, published in October 2016.

The NHS has made a number of initiatives to address this problem, including an Innovation and Technology Tariff.⁶⁴ However, NHS England's innovation priority is the adoption and spread of innovations across the NHS, and therefore, rightly, on innovations that are ready to deploy, wherever they come from. So the alignment of NHS innovation priorities with the national need to support the development of UK based health technology companies is only partial.

Department of Health

SBRI Programme Metrics (Annual Averages 2012/13 to 2015/16)

Competitions: 1; Total Value of Contracts: £6.0m; Number of Projects Funded: 11

Phase 1 Value: £247k; Phase 2 Value: £849k;

Phase 2s as a Percentage of Phase 1s: 42%.

Programme Management

The total Department of Health budget for 2017/18 is £123.5 billion, of which £110 billion is directly managed by NHS England. The DoH's other responsibilities include Public Health England, Health Education and Research and the National Institute of Health Research's £1 billion a year research programme.

The Department of Health was selected as one of two departments to pilot SBRI following its re-launch in 2008.

⁶⁴

The Innovation and Technology Tariff aims to streamline the process of getting innovations into the NHS by removing the need for multiple local price negotiations, and instead guaranteeing automatic reimbursement when an approved innovation is used, while at the same time allowing NHS England to negotiate national 'bulk buy' price discounts on behalf of hospitals and patients. It went live for the first batch of selected products in April 2017.

The two themes chosen related to the threat from MRSA and other hospital infections, which was the subject of much public concern at the time. They focused on Hand Hygiene and Pathogen Detection in the Hospital Environment. The combined budget was £5.1m and competitions were designed and managed by the National Institute for Health Research (NIHR).

Although there were a number of SBRI competitions run by NHS regional Strategic Health Authorities in the next few years, the Department of Health itself did not get engaged in SBRI again until 2012 and competitions have since been on an ad hoc basis.

The Government's *Plan for Growth*, published in March 2011 committed the DoH (including the NHS) to spending £10 million on SBRI over each of the following two years. By this time, NHS England was moving towards becoming an agency non-departmental body with direct responsibility for commissioning budgets.

Funding for the Department's next SBRI came from its Commercial Directorate. Two challenge areas were identified and launched in March 2012:

- Medicines management - supporting people to take the right medicines at the right time and as prescribed (up to £2m);
- Personal behaviour to address the impact of obesity and/or alcohol related health diseases (up to £2m).

As the DoH Commercial Directorate lacked direct clinical or technology programme management expertise, one programme was run with the help of the NHS East and Midlands SBRI team, and the other with the NHS Strategic Health Authority for London.

Following continuing pressure from the Cabinet Offices, in 2013, DH Commercial Directorate launched two further challenges:

- Renal - promoting patient empowerment and sustainability in kidney care, and managed in partnership with Devices for Dignity Health Technology Cooperative (D4D) (£3.6m);
- Enabling technologies for genomics sequence data analysis and interpretation (£10m) managed in partnership with Innovate UK and Genomics England.

Both competition themes were the result of suggestions by senior individuals within the Department.

In October 2016, the Department of Health launched a competition for Vaccines for Global Epidemics. It was originated by the UK Vaccine Network, established in June 2015 to make sure that the UK and the wider international community are better prepared for future outbreaks of infectious disease.

Total funding is £35m and comes from the Department for International Development's Official Development Assistance budget. It will support the clinical development of vaccines up to and including Phase II trials, and it is expected that individual contracts will be worth up to £3 million, with the possibility of larger awards on a case-by-case basis.

CASE STUDY 7: Congenica Limited

In March 2015, Congenica Limited, a Cambridge-based spinout from The Wellcome Trust Sanger Institute, was awarded a £2m Phase 2 contract through the Department of Health/Genomics England SBRI competition to develop Sapienta - a clinical decision tool for diagnosis of rare genetic diseases.

Collectively, rare genetic diseases affect some 6% of the population, three quarters in childhood. The UK alone has 3.5 million people affected. 80% of rare diseases are thought to have a genetic basis. The Sapienta SBRI project will support development of diagnostics for rare genetic diseases with greater accuracy and within a fraction of the time and cost taken by current methods.

Later in 2015 the company raised £2.2m in A round equity funding to help further develop and accelerate growth. It is already receiving revenues from use of the Sapienta platform by clinicians and researchers across the world for clinical diagnosis, prognosis, and research. The company is growing rapidly and is now focussing on the US and Chinese markets. Congenica is currently establishing a centre for global sales and operations in San Diego, and has plans to establish another office on the US East Coast. It raised a further £8m in February 2017.

Ministry of Defence

SBRI Programme Metrics (Annual Averages 2012/13 to 2015/16)

Competitions: 20; Total Value of Contracts: £11.1m; Number of Projects Funded: 132

Phase 1 Value: £68k; Phase 2 Value: £283k;

Phase 2s as a Percentage of Phase 1s: 6%.

Apart from BEIS, the MOD has the largest R&D expenditure of any department. However, this has been more than halved in real terms over the last 30 years, and the bulk of the cutbacks have been in development rather than research.⁶⁵

It awarded more SBRI designated contracts than any other department or agency between 2008 and 2016, with over 950 contracts from 123 competitions valued at £72m. But, though the MOD accounted for 42 per cent of all Phase 1 SBRI awards, it provided less than 7% of Phase 2 spending. The vast majority of these contracts have been at Phase 1 with only 7% of Phase 1s moving to Phase 2. Average contract values over the entire period are £65k for Phase 1 and £210k for Phase 2, less than the minimum SBRI guideline. Though there has been some increase in Phase 2 funding recently, the overall picture remains broadly unchanged.

Two branches of the MOD have been involved, the Centre for Defence Enterprise, recently superseded by the Defence and Security Accelerator, and Defence Equipment and Support.

Centre for Defence Enterprise/Defence and Security Accelerator SBRI

The Centre for Defence Enterprise in Harwell was set up in 2008 to enable the MOD to engage better with innovators from outside its traditional supply base, including SMEs and universities. In December 2016, CDE was superseded by the Defence and Security Accelerator, like CDE, part of the Defence Science and Technology Laboratory (Dstl),

⁶⁵ *Creating Markets for Things that Don't Exist: The Truth About UK Government R&D and How the Success of SBRI Points the Way to a New Innovation Policy to Help Bridge the Valley of Death and Rebalance the UK Economy.* David Connell. Centre for Business Research. Cambridge Judge Business School, 2014.

whose scientists and engineers have deep expertise across a wide range of technologies and which provides the point of access for CDE to internal MOD customers.

The formal aim of CDE was “to fund novel, high risk, high potential benefit research to develop cost effective capabilities for UK armed forces and securities”.

It ran themed competitions and an Enduring Challenge programme to attract innovator initiated ideas. Themed challenges were typically identified by Dstl technical leads, based on an assessment of where scientific and technological innovation offered the greatest potential benefits to MOD. CDE also ran challenges in collaboration with other departments and agencies, including the Home Office, Department for Transport and Innovate UK, where there was an overlap with their interests. Themed competitions have included:

- Additive manufacturing for future military equipment;
- Automating cyber defence responses;
- Autonomy in hazardous scene assessment;
- Defence medical sciences;
- Detection of airborne chemical hazards and persistent surveillance.

CDE SBRI competitions started with a briefing day, where companies could meet Dstl technical specialists to discuss their applications. Contracts were awarded following a paper-based assessment, and recipients included universities, small businesses and large companies. Across all of its external spending, which included programmes other than SBRI, CDE awarded 28% of contracts to academia; 29% to established defence companies; and 43% to SMEs.

From 2014, Dstl project managers have had to commit to planning for Phase 2 funding when launching a Phase 1 competition. This has led to an increase in two phase competitions. CDE contracts were occasionally followed by direct Dstl funding on behalf of its customers. However, data on the number and value of follow-on Dstl contracts is not available and from discussions with Dstl, I do not believe the amounts were significant in the context of SBRI.

For some years CDE has focused efforts on research to develop future “capabilities”. That is to say, technologies and expertise that enable the MOD to improve its effectiveness in specifying procurement requirements, evaluating supplier propositions and negotiating acquisitions. Contract deliverables are typically at technology readiness level 4, or a little higher for Phase 2s. Dstl rarely funds third party developments beyond this unless there is an urgent or UK specific requirement which cannot be readily met through existing products. When it does so it is generally through development contracts with established specialist defence contractors. In practice, the MOD mainly relies on prime and first tier contractors, either to acquire the component and subsystem level innovative technologies

needed on the global market, or to fund developments themselves as part of turnkey contracts.

CASE STUDY 8: Traditional Weaving Methods Enabling Electronics to be Woven into Soldiers' Uniforms

Intelligent Textiles was set up by fabric designer Asha Peta Thompson and Dr Stan Swallow, a lecturer at Brunel University with a background in electronic engineering. They developed a way to weave electric circuits capable of transmitting power and data directly into fabrics, creating the potential for a range of applications.



After attempting to commercialise the technology from within the university, Asha and Stan instead decided to buy the patents and spin out an independent company. They explored many uses for their innovation, such as snowboarding jackets with integrated controls, before contact with the Canadian military at a trade show highlighted the potential for defence applications.

Intelligent Textiles won support from SBRI through the MOD's Centre for Defence Enterprise to demonstrate how their innovation could reduce the weight of equipment that soldiers carry on the battlefield. Currently, separate batteries are required for each piece of a soldier's equipment, so they can be forced to carry up to 50 batteries of various sorts.

Intelligent Textiles created an 'e-uniform' where a flexible circuit board is woven into clothing fabrics to connect together all of the soldier's equipment. This reduced the weight and number of batteries and removed the risk of wires and cables tangling and snagging. The support also enabled them to make the technology less conspicuous, using electromagnetic screening to prevent soldiers being detected by enemy troops while wearing their uniform.

Following their support from the Centre for Defence Enterprise, Intelligent Textiles began working with BAE Systems. Entering into a licence agreement with Intelligent Textiles, BAE Systems developed the 'Broadsword Spine' product for service personnel, law enforcement and first responders. Broadsword Spine is currently undergoing trials internationally and is being readied for mass production. All major components of the Broadsword Spine are produced by an entirely UK-based manufacturing chain, involving at least six companies from different sectors, from textile manufacture to electronics to garments. Intelligent Textiles is exploring the potential for applications in other areas, such as healthcare products.

The CDE strategy to focus on research up to mid-range technology readiness levels reflects the proliferation of new technologies about which Dstl needs to be aware. It is an entirely logical way in which to use its limited resources in the best interest of the nation's defence and security.

Collaboration with Subcontractors

Most defence technology innovations are commercialised within the supply chain rather than being purchased directly by the MOD. Dstl has collaborated with prime contractors in some SBRI competitions to assist this process.

The Autonomous Systems Underpinning Research (ASUR) Programme was managed on behalf of Dstl by BAE Systems and a consortium including Rolls Royce, Selex ES, Thales, MDBA, Roke Manor and Qinetiq. Two SBRI challenges in 2013 and 2014 funded 59 Phase 1 and 19 Phase 2 projects. The programme closed with a showcase and conference in September 2016.

The Sensing for Asset Protection with Integrated Electronic Networked Technology (SAPIENT) project was a £3m collaborative project between Innovate UK and Dstl to deliver innovative research towards autonomous modular sensing. In late 2015, the programme announced it had demonstrated an autonomous sensor system which could significantly reduce the operator burden involved in perimeter protection and security. Dstl and Innovate UK are now working with industry partners to exploit these technologies further for military and civilian security applications.

Dstl hosted regular 'CDE Marketplace' events at which companies could present their project's results to prime contractors, Dstl project teams and MoD stakeholders. These events were designed to help companies find partners, customers and other funders, as in most cases neither CDE nor Dstl was able to provide funding for companies to develop a deployable product.

Defence Equipment and Support SBRI

The March 2013 budget assigned the MoD targets for SBRI spending of £50m in 2013/14 and £100m in 2014/15. In response to this, MOD examined how to achieve additional use of SBRI from procurement rather than R&D budgets and DE&S (Defence Equipment & Support) became involved.

DE&S was formed in 2007 following the merger of the Defence Procurement Agency and the Defence Logistics Organisation. Launched as a Bespoke Trading Entity in April 2014, DE&S manages a wide range of complex projects to deliver equipment and support to the UK's Armed Forces. This ranges from submarines, warships, aircraft and missiles, through to armoured vehicles, utility trucks, body armour and field kitchens. The MOD delegates the bulk of the equipment budget to commands, like the Army. DE&S manages the acquisition and through-life support of equipment on behalf of its customers. Its corporate plan emphasises the importance of effectively enabled innovation.

The DE&S SBRI competitions have focused on topics where component level technologies can be moved from R&D to procurement fairly rapidly, such as more effective maintenance tools to reduce maintenance and repair down times. The first DE&S SBRI challenge was the Land Vehicle Exercise in 2013 aimed at improving the Mounted Close Combat Capability of land vehicles returning to Contingent Operations.

In late 2014, the Cabinet Secretary wrote to departments asking them to identify challenges suitable for SBRI. As a result the MOD ring-fenced £5 million for three new challenges;

- Fuel and lubrication systems;
- Non-destructive testing for in-service or in-storage equipment;
- Enhanced individual protective equipment for harsh, toxic and hostile environments.

DE&S also ran a competition in 2014 on opportunities presented by the emergence of Global Navigation Satellite Systems (GNSS) for both military and civil applications. This was co-funded by Innovate UK with up to £650k available. There were four Phase 2 contracts, three of which are with MOD prime contractors, and one with a university spin out company.

Recent Developments in MOD Innovation Strategy

As part of the 2015 Strategic Defence and Security Review, MoD committed to spending 1.2% of its budget on science and technology. And in September 2016, it launched the Defence Innovation Initiative to improve its approach to innovation, risk and procurement. One of the key principles of the Initiative is to accelerate promising innovations from idea to solution, rapidly pulling through low TRL ideas into “fieldable” solutions.

Key components of the Initiative include a Defence and Security Accelerator, to build on and supersede the CDE operation, and a ten year Defence Innovation Fund of up to £800m. This incorporates a £150m “innovation pipeline fund”, available up to 2020. There is also a commitment to spend 20% of the MoD science and technology budget on “disruptive capability”.

Launched in December 2016, the Defence and Security Accelerator will continue to use SBRI alongside other programmes. It plans to involve procurement bodies and customers, and established defence contractors, at each stage in the competition process to encourage collaboration and provide a clear route to commercialisation for the best projects. It also plans to provide business advice to funded companies.

At the time of the Review, the Accelerator had launched four competitions. The budgets available indicate that though there may be a higher proportion of projects going through to Phase 2 than previously, individual contract values will generally remain much smaller than the US SBIR programme and insufficient to take successful projects to a commercially meaningful milestone.

Although the Defence Innovation Fund represents an important commitment, it has an ambitious and wide ranging remit, and it is expected to fund a variety of activities within its very broadly defined “innovation” remit. It will “take forward the best proposals, from inside and outside of Defence, in an open competitive process. It will not seek to favour specific areas of innovation (for example technological, procedural), but will enable as broad a scope of innovation as possible”.⁶⁶

Detailed plans for the Fund, and the precise mix of mechanisms to be used, are still being drawn up, but my discussions with officials suggest that the amounts available for developing innovative products through SBRI are likely to be quite limited.

Comments

The strategic approach to innovation underpinning the Defence Innovation Initiative and the new Defence and Security Accelerator promises important improvements on past practice. However, from my discussions with MOD staff, it is clear that it will not be in the interests of Dstl (or the Accelerator), given its limited funding and wide range of responsibilities, to change its strategy of focusing SBRI funding on early stage R&D, or to increase the average value of Phase 2 contracts to a size equivalent to the US Department of Defense’s SBIR. It will continue to rely on its government customers and established private sector contractors to fund the conversion of early stage project outputs from SBRI into products that can be procured for operational deployment or incorporated into larger systems. However, it is not clear why either should be any more willing to do this than in the past, given the limited prior investment made to demonstrate the potential of innovations through the MOD SBRI. More substantial Phase 2 SBRI contracts and

⁶⁶ *Defence Innovation Initiative Information*; MOD, May 2017.

some Phase 3s are likely to be required to achieve this, as in the US DoD SBIR programme.

SBRI funding for shorter lead time technologies, such as those falling within the DE&S SBRI is also unlikely to grow significantly. Indeed, at the time of the Review no further DE&S SBRI's were planned. As a result overall MOD SBRI funding appears unlikely to be materially changed as a result of these new initiatives, and the paucity of Phase 2, let alone Phase 3, funding will continue to limit the potential benefits of the DE&S SBRI programme to both the MOD and UK SMEs.

The lack of MOD funding between TRL4/6 and TRL 8 for UK defence and security innovations, and the weak demand pull through that results, represents a major missed opportunity to accelerate the rate of creation and growth of those STEM based UK SMEs for whom defence and security represent important international markets in their own right, as well as lead applications of technologies with wider applications.

BEIS Energy Innovation Programme (Previously DECC)

SBRI Programme Metrics (Annual Averages 2012/13 to 2015/16)

Competitions: 2; Total Value of Contracts: £9.2m; Number of Projects Funded: 20;

Phase 1 Value: £34k; Phase 2 Value: £1m;

Phase 2s as a Percentage of Phase 1s: 41%.

Apart from a couple of very small competitions, DECC did not begin to use SBRI systematically until 2012, when an Energy Innovation budget of £160m was established to fund programmes on low carbon technologies over the next three years.

An experienced manager was recruited from the defence industry to run the programme, with in-house engineering expertise and project managers to oversee competitions and projects.

The Energy Innovation Programme deploys a mixture of funding mechanisms depending on the technology and its proximity to market. These range from early stage R&D grants to investment in near-market ready technologies via its Energy Entrepreneurs Fund. This is a grant based programme offering up to £600k per project and operating under EU State Aid regulations. Total Energy Innovation funding is split approximately equally between R&D grants, SBRI and the EEF.

The Energy Innovation Programme team has found SBRI to be a useful mechanism to stimulate innovation, particularly in niche areas where there is currently little private sector investment interest – for example in battery storage.

SBRI competition themes since 2012 include:

- Advanced Heat Storage
- Greenius Award to Supply Clean, Green and Reliable Energy (co-funded with DEFRA)
- Wetlands Biomass to Bio-Energy
- Invest in Innovative Refurbishment (run by Innovate UK)
- Energy Storage Demonstrator
- Heat Networks Demonstrator.

The team has also co-funded a Welsh Government competition on Portable Renewable Energy Generation.

The use of SBRI in DECC is now well-established, and competitions are often delivered without direct Innovate UK support. Competitions follow a standard process with an open day, followed by a paper-based assessment for Phase 1. Phase 2 selections are based on the results of project monitoring and sometimes interviews. Any SMEs taking part are also offered business incubation support under a programme originally developed for Energy Entrepreneur Fund winners.

In some cases a return on the funds committed is sought from the sale of demonstrators.

The Wetlands Biomass Project is an example of where the team has collaborated with partners, in this case the Royal Society for the Protection of Birds (RSPB), to dispose of biomass generated across the Society's managed wetland sites while using it to generate electricity. The three companies awarded Phase 2 contracts each successfully demonstrated anaerobic digestion technologies and an end-to end supply chain in demonstrators located in the Somerset Levels and the Fens.

An additional benefit for companies taking part was the connections made to regulators, potential customers and partners within the energy sector.

Department for Transport

SBRI Programme Metrics (Annual Averages 2012/13 to 2015/16)

Competitions: 2; Total Value of Contracts: £1.5m; Number of Projects Funded : 13;

Phase 1 Value: £62k; Phase 2 Value: £458k;

Phase 2s as a Percentage of Phase 1s: 12%;

The Department for Transport (DfT) is supported by 19 agencies and public bodies. The roles of these business units include maintaining England's 4,300 miles of motorway and truck road network, setting and maintaining driver and vehicle safety standards, building a multi-billion pound high speed rail network, creating and implementing transport policy, providing a search and rescue helicopter service, managing the nation's maritime and railways sectors, and supporting a £10 billion aviation industry. The Department operates a Group Operating Model (GOM) for its procurement function whereby its non-departmental public bodies (NDPB) and executive agencies work collaboratively with the procurement function in the core Department (known as Group Procurement) and each other as 'one team'. SBRI is led from within Group Procurement.

DfT was an early adopter of SBRI. Its Chief Scientific Advisor's unit ran a competition in 2009 with what was then the Highways Agency (now Highways England) to explore ways in which *synthetic environments* (i.e. virtual reality) could be applied to motorways. The project emphasis was on modelling how drivers respond to traffic controls and each other during peaks times. Three companies were awarded £100,000 contracts to develop solutions funded from DfT's Research and Development budget.

There were no further SBRI competitions until 2013, following the introduction of SBRI targets for 6 departments in the 2013 Budget. In response to the target, Group Procurement worked with the Chief Scientific Advisor's Unit to identify challenges across the Department where SBRI could play a role, and developed an SBRI programme plan, which included building awareness of SBRI across the GOM. To date, the Department's SBRI projects have predominately focused on the rail sector, where opportunities for innovation are regarded as particularly rich and an existing innovation budget existed.

Opportunities in the Rail Sector

The Technical Strategy Leadership Group, an expert body with representatives from across the rail industry, developed the Rail Technical Strategy 2012. The strategy majored on innovation, and was supported by a new Transport Catapult along with an 'Enabling Innovation Team at Future Railway', part of the Rail Safety and Standards Board (RSSB). The Enabling Innovation Team, now just known as RSSB, receives grant funding

from DfT to carry out a broad range of activities from running competitions for technology feasibility and demonstration projects through to support for organisations, and initiatives, to foster a culture of innovation within the rail industry. The latter are referred to as ‘enabling activities’. To date, RSSB has been commissioned to deliver 6 rail SBRI competitions on behalf of DfT.

Competition	Award Date (Phase 1)	Overall Budget
Aesthetics of Over Line Electrification	Apr-2014	£600K
Avoidance of Bridge Reconstruction	Jun-2014	£2,600K
Tomorrow’s Train Today	Jul-2014	£2,650K
Braking	Feb-2015	£4,000K
Powertrain	Mar-2015	£4,000K
Compass (alternative signalling)	Jun-2015	£4,000K

These competitions aimed to achieve benefits through innovation including:

- Developing and demonstrating sustainable overhead line electrification designs that are less visually obtrusive;
- Addressing the significant costs associated with bridge reconstruction that are commonly required to allow overhead electrical lines to pass beneath existing bridges and tunnels where clearances are limited;
- Developing new design solutions for adjustable interiors and improved trains to address the challenges facing the UK rail industry, potentially facilitating new business models, better utilisation of rail vehicles during peak and off peak times, and challenging existing railway standards;
- Providing consistent and safe braking systems that function in all weather conditions. This capability is not only important on its own, but is also an essential forerunner to future rail traffic management systems;
- Developing alternative powertrain technologies for self-powered vehicles to replace the aging diesel fleet;
- Providing signallers with a tactical picture of the railway, identifying the position of trains at any given point, thus allowing for improved operations in situations where the primary signalling system has failed. This has the knock-on effect of reducing

disruption to the travelling public and a reduction in delay payments for Network Rail.

DfT usually runs an expression of interest stage before the two phase SBRI process. A total of 60 contracts have been awarded with 9 at Phase 2. Given the dominance of long established engineering companies in the rail sector, the number of small and medium-sized enterprises awarded contracts has tended to be limited. To date all rail projects funded are regarded as successful, although none have yet achieved product sales, reflecting the long SBRI procurement and testing cycles in rail transport infrastructure, and the need to engage supply chains.

SBRI Outside Rail

In 2016, DfT supported a Welsh Government SBRI competition: *A Cute Solution to Acute Anxiety in Dementia*. This competition aims to develop innovative solutions that could assist people who are living with dementia and experiencing high levels of anxiety when travelling to and from hospital. The competition is being run as a two-phase process, with businesses able to bid for development contracts of up to £50k in Phase 1 (Proof of Concept) and up to £175k in Phase 2 (Demonstrator Projects). DfT has contributed £120k towards the competition.

In addition, DfT provides annual funding to security related SBRI competitions with the Home Office, and has a number of other SBRI competitions in the pipeline spanning areas ranging from transport security to cycling.

NC3RS - The National Centre for the Replacement, Refinement and Reduction of Animals in Research

SBRI Programme Metrics (Annual Averages 2012/13 to 2015/16)

Competitions: 3; Total Value of Contracts: £3.4m; Number of Projects Funded: 10;

Phase 1 Value: £99k; Phase 2 Value: £854k;

Phase 2s as a Percentage of Phase 1s: 27%.

NC3Rs is an independent scientific organisation, established in 2004, dedicated to replacing, refining and reducing the use of animals in research and testing. It has an annual budget of around £10 million and receives core funding from the Medical Research

Council (MRC) and the Biotechnology and the Biological Sciences Research Council (BBSRC). It also receives funding for specific programmes from the charitable, commercial and industrial sectors.

In 2011, the NC3Rs launched the CRACK IT challenge-led funding competition programme using SBRI. It has a permanent programme management team of three.

CRACK IT aims to:

- fund collaborations between industry, academics and SMEs (by supporting consortia with either an SME or academic leading);
- minimise the use of animals in research;
- support the development of marketable products and/or improved business processes.

NC3Rs works with sponsors to help identify and refine CRACK IT challenges. Sponsors provide in-kind contributions, including data, compounds, access to specialist equipment, and occasionally co-funding, to support the development of new tools to address their challenge. Challenge sponsors have included GlaxoSmithKline, Lilly, Novartis, Roche, Syngenta, Unilever, Pfizer, AstraZeneca and Alzheimer's Research UK, as well as Dstl. Challenge do-funders have included Arthritis Research UK, EPSRC, Innovate UK and MRC.

NC3Rs identifies challenges through an open call and dialogue with stakeholders. A CRACK IT Advisory Panel assesses potential challenges and recommends which ones NC3Rs should run as competitions. Challenges are developed jointly by the NC3Rs team and the sponsors, and launch events enable potential applicants to meet sponsors and identify new partners.

CRACK IT challenges are run using the standard two phase model: Phase 1 funds up to three proof-of-concept studies per challenge, each with up to £100k over six months. The assessment of Phase 2 proposals includes a '*Dragons' Den*' style interview panel. A single Phase 2 contract is awarded per challenge, worth up to £1m over up to three years.

CASE STUDY 9: Actual Analytics

Actual Analytics, a spin out company from the University of Edinburgh, was founded in 2010 with £900k of seed capital, to develop and market video based analysis techniques in animal trials to address a key bottleneck in drug development. Between 2012 and 2014 it was awarded £1.1m over two CRACKIT competitions to develop an innovative home cage analysis system that delivers automated analysis of complex behaviours of group housed rodents in their *real home cage*, whilst retaining the individual identity of each rodent and monitoring them 24/7 for weeks or months at a time. This technology accesses and analyses data previously unobserved by conventional methods and substantially improves animal welfare during research.

AstraZeneca, as sponsor, provided evaluation, optimisation and validation studies in rats and the Medical Research Council, Harwell provided a similar evaluation for the mouse system in their laboratories.

So far, Actual Analytics have their systems deployed in some of the world's most prestigious universities, research facilities, pharmaceutical companies and contract research organisations across the UK, Europe and America.

Home Office

SBRI Programme Metrics (Annual Averages 2012/13 to 2015/16)

Competitions: 3; Total Value of Contracts: £2.4m; Number of Projects Funded: 21;

Phase 1 Value: £58k; Phase 2 Value: £217k;

Phase 2s as a Percentage of Phase 1s: 27%.

The Home Office's responsibilities include immigration, counter-terrorism, police and drugs policy. Its SBRI programme is coordinated by the Home Office Science (HOS) directorate. HOS works closely with other policy directorates and operational commands across the

Home Office, and individual projects are managed and funded by these business areas. To date these have included:

- OSCT (Office of Security and Counter Terrorism);
- Border Force;
- Competitions held in partnership with the Intelligence Agencies (MI5, MI6, GCHQ).

Competitions to date have included:

- Mobile Device Security (m-Commerce);
- Roadside Drug Detection;
- Have I Got 'Views' for You (Social media tracking);
- Explosives and Weapons Detection;
- Detection of Clandestines;
- Secure Working in Insecure Environments;
- Security for the Internet of Things (IoT);
- Digital Forensics;
- Automatic Threat Detection of Firearms;
- The Future of Aviation Security.

Two competitions on explosives and weapons detection were managed and co-funded by the Home Office Centre for Applied Science and Technology (CAST) in collaboration with the Department for Transport (DfT), the Centre for the Protection of National Infrastructure (CPNI), Metropolitan Police Force, the Defence Science and Technology Labs (Dstl), with which CAST has a close working relationship, and the US Department for Homeland Security.

The UK has particular strengths in security science and technology, but, rather like the MOD, Home Office SBRI budgets are small and spread thinly. Despite some very promising projects, very little Phase 2 funding has generally been available.

Companies awarded Home Office contracts to date include:

- Ancon Technologies Ltd, based in Canterbury, which offers revolutionary new molecular detection technology with very high levels of sensitivity for concealed explosives detection;
- The Imagination Factory, a London based product design engineering agency, which won a contract from Border Force's "Detection of Clandestines" and has developed an improved approach for detecting people hidden in hard-sided vehicles, and received subsequent orders for the product;

- Alpha Fox Systems, a company based in the South West of England, that has developed an anti-counterfeiting, identification tag' for mobile commerce personal authentication (Crystal Key™).

CASE STUDY 10: RepKnight Limited

Belfast based RepKnight is a cyber security company set up to develop and apply technology for monitoring high volumes of social media messages in real time. Its early development was funded with revenues from founder, John Reid's, personal consulting business. While RepKnight was still a pre-revenue, part-time business, he entered the "Have I got Views for You" SBRI competition, run by Innovate UK in conjunction with the UK Office for Security and Counter Terrorism. A £100k Phase 1 contract in 2011 led on to £500k plus follow on contracts from the OSCT to develop and deploy a demonstrator system to help the Metropolitan Police identify potential disruptions in the run up to the 2012 Olympics.

Since then the technology has been further developed to access the larger corporate market for rapid detection of breaches in personal data and communications security. Since its formation the company has raised £6.8m in investments and grown to 35 people. RepKnight founder John Reid participated in trade missions to the US and Asia led by David Cameron in 2015 and 2016.

Innovate UK

SBRI Programme Metrics (Annual Averages 2012/13 to 2015/16)

Competitions: 3; Total Value of Contracts: £7.6m; Number of Projects Funded: 28;

Phase 1 Value: £127k; Phase 2 Value: £741k;

Phase 2s as a Percentage of Phase 1s: 20%.

The largest portion (22%) of total government SBRI expenditure to October 2016, £76m, came from Innovate UK. Around £26m represented co-investments alongside other

sponsors as pump priming to introduce them to the SBRI model. Some of the remainder was for competitions run on behalf of spending departments, but funded by Innovate UK.⁶⁷

As well as supporting the use of SBRI across government, Innovate UK has used SBRI as a mechanism to achieve its own policy aims. In the period from the launch of SBRI in 2009 to October 2016 it has run 18 SBRI competitions. These competitions have predominately fitted within or above the funding guidelines for SBRI and have awarded 376 Phase 1 contracts totalling £21.1m and 181 Phase 2 contracts totalling £55.2m.

Innovate UK SBRI competitions have been in various sectors, but primarily in Health and Social Care, and in Cities and the Built Environment.

The largest of these was the £18m Retrofit for the Future competition, run in collaboration with the Department for Communities and Local Government. This funded 87 different demonstrators of designs and technologies to reduce the carbon footprint of older social housing. This competition had a very different profile to other SBRI. It provided a mechanism for funding small independent designers and builders to demonstrate innovative approaches to refurbishing and renovating older houses which would not have been possible using traditional grant funding instruments.

An example in the Healthcare arena was a Stratified Medicines Competition which awarded £8m across 12 Phase 1 contracts and 4 Phase 2 contracts. The aim of the competition was to accelerate and/or increase the development and adoption of innovative diagnostic tools in order to offer better targeted treatment to patients within the UK healthcare system. It also aimed to demonstrate the benefits of companies working within the UK enabling infrastructure, which is made up of specialist organisations that can help companies understand healthcare needs and design, evaluate and deliver their products and services into the NHS.

⁶⁷ *A Review of the Small Business Research Initiative*, Manchester Institute of Innovation Research with the Enterprise Research Centre and OMB Research Ltd, 2017.

CASE STUDY 11: Q-Bot Ltd

Q-Bot Ltd was formed in 2012 by architect Tom Lipinski and two engineers, Peter Childs and Mathew Holloway. Tom and Mathew had both been involved in starting other clean energy businesses and saw a significant opportunity for retrofitting underfloor insulation to the ten million or more buildings with suspended floors and poor energy efficiency for which conventional techniques were inappropriate. An approach using an automated underfloor robotic crawler appeared to offer a possible solution.

During the first year or so they developed a prototype machine in-house based on existing commercially available engineering and software components. Grants from Innovate UK and DECC helped fund this work alongside small scale equity investments and sweat equity from the founders.

Q-Bot uses a robot inserted through an air vent to survey voids and apply insulation to the underside of floorboards. Previously, the only way to insulate floorboards was to lift them – an expensive and disruptive procedure.



In 2014 Q-Bot won Phase 1 and 2 SBRI contracts totalling around £150k from the Heritage Retrofit SBRI competition run by the Welsh Government alongside Innovate UK and Cardiff City Council. This was aimed at encouraging both energy efficiency and protecting and enhancing the historic built environment. Crucially it enabled Q-Bot to be trialled in a listed building owned by the City Council, providing independent and systematically verified data on the installation costs and practicality of the approach, together with costed energy savings.

In March 2016 Q-Bot secured an EC SME Instrument grant worth €2.1m, providing vital finance to scale up the business. As discussed in Chapter 4, like SBRI this new, and highly regarded, scheme is “inspired by the US SBIR”.

To date, roughly 20% of Q-Bot’s funding has come from customer revenues, with a further 20% from equity investment, mainly from individuals. Grants and the SBRI contracts have provided the rest. Contract sizes and customer interest are growing rapidly, especially amongst social housing providers. Sales opportunities are also emerging elsewhere in Europe and the US.

Devolved Administrations

A good deal of enthusiasm has emerged for SBRI in all three devolved administrations, though budgets are usually relatively small and there is the added complexity, from an economic policy point of view, that a large proportion of award winners are likely to be from other parts of the UK.

Northern Ireland

Northern Ireland has used SBRI since 2010, and the programme has had high-level ministerial and Assembly Committee support.

A competition by the Northern Ireland Tourist Board led in 2011 to the launch of the My Tour Talk app which provides walking and audio tours for major Ulster attractions produced by a Belfast start-up, OLI (Outside Looking In). A second tourism app funded through a Welsh Government SBRI was followed by the business forming a partnership with The Guardian Newspaper Group, to develop fifteen digital destination guides, branded as 'Snout'.

"Sustainable Use of Poultry Litter" was a much larger Northern Ireland SBRI competition which sought to prevent the Northern Ireland Poultry Industry, which employs 6000 people, breaching its environmental requirements. Two companies led projects through Phases 1 and 2 to develop prototype anaerobic digestion technologies. The Northern Ireland government also provided loan financing which enabled these companies to build near-commercial scale demonstrators.

The Northern Ireland Government established a competitive, central, ring-fenced, £1.1m Challenge Fund in 2016/17 to fund proposals for SBRI competitions from different parts of the public sector. There was an enthusiastic response from potential SBRI sponsors within the Administration, and the Fund was oversubscribed. Of the fifteen bids, it was able to fund five SBRI competitions, including 3 specifically targeting the application of data analytics to solve public policy problems.

Wales

After some small scale SBRI the Welsh Government established a central fund in 2013 - the Wales SBRI Catalyst Programme. Rather like the Northern Ireland Challenge Fund, this sought challenges from Welsh public sector 'problem owners', which were then assessed on a competitive basis to allocate funding.

The percentage of funding provided by the central Catalyst Fund was reduced from 100 % in call 1 to 80 % in call 2. This was partly aimed at increasing the ownership and involvement of individual departmental challenge owners. However, lowering the central contribution led to a reduction in applications as departments found it difficult to find their 20% contribution.

Scotland

Wave Energy Scotland, run by Highlands and Islands Enterprise, is the largest pre-commercial procurement scheme in Scotland. It was launched in 2014 to develop innovative solutions at component or sub-system level for the conversion of wave action to electrical power. It has since awarded £15m to 51 projects through a competitive programme very similar to the SBRI model

NHS Scotland, in conjunction with Scottish Enterprise, started to use SBRI in 2015.

Scottish Enterprise is developing ideas for a four-year 'Central Scotland Fund' for SBRI based on lessons from Northern Ireland and Wales.

Appendix 2 - Terms of Reference for Independent Review of the Small Business Research Initiative (SBRI)

Context and background

1. Small businesses often struggle to fund the development of new innovative products, and to access government procurement opportunities. SBRI is an existing competition-based programme, managed by Innovate UK, which aims to overcome these barriers by providing businesses with government R&D contracts to develop new solutions for public sector challenges.
2. The primary purposes of SBRI are:
 - to stimulate innovation in the economy by supporting firms to develop and commercialise new technology-based products and solutions;
 - provide government departments and their agencies with new, cost-effective, technical and scientific solutions.
3. SBRI is based on a longstanding US programme - SBIR - which provides around \$2.5 billion each year in funding to SMEs to develop solutions for federal department needs. However, the UK scheme has not reached a comparable scale of activity and has been weaker at supporting firms to achieve wider commercialisation and procurement opportunities. Since 2009, the UK's SBRI has provided around £320m of contracts and led to the development of a range of innovations, and it is currently awarding around £50m of contracts a year

Aim of the Review

4. The independent review will examine how we can maximise the impact of the SBRI programme to improve procurement outcomes for government and support and stimulate innovation by SMEs, boosting the UK's innovative capability, and support the development and commercialisation of new technology-based products and services in the UK economy.

5. Specifically, the review will:

- Explore how the US SBIR programme realises its aims and achieves its impact, its strengths and weaknesses, and identify key lessons and best practice that can be translated to the UK;
- Consult businesses on their experience of accessing and using the SBRI programme, and identify how processes can be improved;
- Examine how different government departments and agencies have, and could, used SBRI to achieve better procurement outcomes and position it against their other R&D activities;
- Look into the barriers that have so far inhibited expansion of the SBRI programme in the UK and identify solutions to overcome them;
- Examine how SBRI could provide better support for follow-on commercialisation and procurement opportunities;
- Assess how SBRI is positioned in the innovation and public procurement policy landscapes, including the potential for linkages with other instruments, such as the new innovation partnership procurement procedure;
- Make clear recommendations for enhancing and improving the SBRI programme in the UK, evidencing value for money.

Governance and resources

6. The review will report to Jo Johnson, Minister of State for Universities, Science, Research and Innovation at the Department for Business, Energy & Industrial Strategy.

7. It will conclude by Spring 2017.

8. The report should be evidence based. It should provide the opportunity for businesses, groups and individuals to contribute their views. It should engage closely with the major procurement departments including on emerging recommendations. Recommendations should be based on evidence which clearly demonstrates value for money.

9. The review will be supported by a small secretariat from BEIS, and will also draw on support from the SBRI team at Innovate UK and from the Crown Commercial Service Procurement Policy Team.

BEIS November 2016