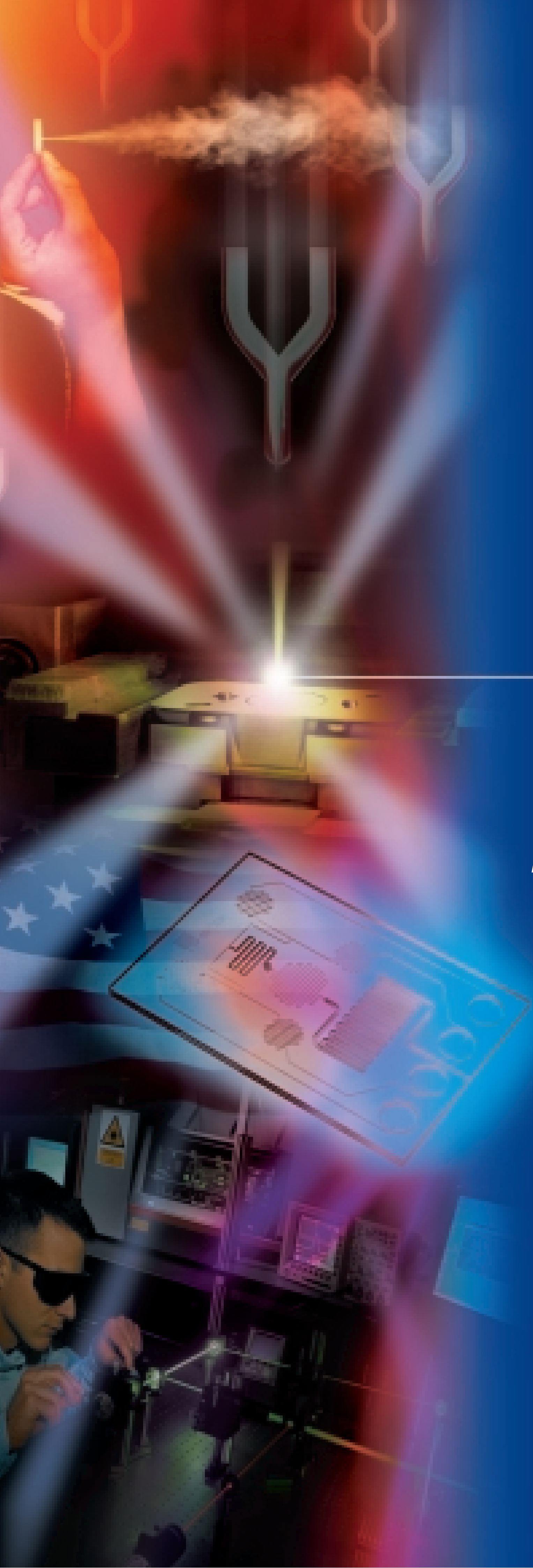

# "SECRETS" OF THE WORLD'S LARGEST SEED CAPITAL FUND:

## *How the United States Government Uses its Small Business Innovation Research (SBIR) Programme and Procurement Budgets to Support Small Technology Firms*


**By David Connell**

Centre for Business Research,
University of Cambridge

Images on cover courtesy of TTP Group plc

## ABOUT THE AUTHOR

David Connell joined the Centre for Business Research as a Senior Research Associate in June 2006, and has been involved in many different aspects of the exploitation of science and technology during his career. He was co-founder and Chief Executive of TTP Ventures - a highly regarded, Cambridge-based, early stage investor in science and technology based companies, which was established in 1999 with backing from Boeing, Siemens and financial institutions. David has been involved in more than 20 of its investments, in fields ranging from drug discovery to semiconductors and scientific instruments. They include spin-outs from Toshiba, QinetiQ and Aventis as well as from smaller companies and universities.

Before becoming a venture capitalist, he was Head of the Strategy Consulting arm of TTP Group, one of Cambridge's most successful "soft" technology companies. Previously, he was responsible for the Deloitte Haskins and Sells High Technology Group, based in the City of London.

During his work as a consultant, David's work focused on innovation, R&D strategy, new business development and corporate venturing. His clients included large companies like IBM, ICI, BP, Zeneca, Nortel, Shell and BNFL, small and medium sized technology companies, and public sector organisations.

Throughout this period, David combined these commercial roles with research and publications on strategy and policy issues facing the science and technology sector.

Today, alongside his academic research interests, David has a continuing non-executive role with TTP Ventures, as a Director of its General Partner, and is an advisor to the boards of a range of small technology companies.

In December 2004, David launched a campaign in conjunction with Anne Campbell (then MP for Cambridge) to persuade the UK Government to introduce a US-style SBIR programme. This was supported by a group of high-profile scientists, entrepreneurs and venture capitalists. The campaign achieved partial success in March 2005 when a key element of the proposals was included in the Budget. The campaign to introduce underpinning legislation similar to that in the US has continued, with Kitty Ussher, MP for Burnley, picking up the political baton from Anne Campbell.

David's first degree was in Physics from Bristol University. He also has Masters Degrees in Operational Research and Economics, both with Distinction, from the Universities of Lancaster and London respectively.

## ABOUT THE CBR

The Centre for Business Research (CBR) is an independent research institution within the University of Cambridge.

It began originally as the Small Business Research Centre, and to this day, the study of enterprise and innovation remain key areas of research, alongside work on corporate governance. **(www.cbr.cam.ac.uk)**

# "SECRETS" OF THE WORLD'S LARGEST SEED CAPITAL FUND:

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## SOURCES

The detailed findings and analysis in this report are likely to be new to most people outside the United States SBIR community. However, the US SBIR programme, and indeed the workings of the US government generally, are really not secret at all, but highly transparent, much more so than in the UK. The problem for researchers is finding and analysing the relevant pieces of information from all that is available, not its availability per se.

Much of the information in this report is available from US government websites relating to the SBIR programme and the reader is referred to a list of these provided in the Appendix. Where specific references are more difficult to find, these are referred to individually as footnotes to the text.


## ACKNOWLEDGEMENTS

In researching this report I have had help from a number of those involved in the US SBIR programme. In particular, I would like to thank Kesh Narayanan of the National Science Foundation, Charles Cleland of USDA, Major Kenneth Strayer of the US Army and Connie Jacobs of DARPA. David Metzer, a Partner in Holland and Knight LLP, provided useful insights into the early history of the programme and the operation of Phase III contracts, and Del DelaBarre of DelaBarre Associates provided invaluable help in introducing me to many people engaged with SBIR at one of the national conferences he organises on the topic. Charles Wessner of the National Research Council of the National Academy of Sciences also provided helpful guidance.

I have a continuing debt to Anne Campbell for helping put the issue on the political map when she was MP for Cambridge and to Kitty Ussher, MP for Burnley, for her support for getting a US-style SBIR programme established in the UK.

Special thanks go to Alan Hughes, Andy Cosh and Simon Deakin at the Centre for Business Research in Cambridge for supporting publication of the report, to Rachel Simpson for editorial and other assistance, to Dianna Butler for converting my hieroglyphics into the printed word, and to TTP Ventures for allowing her to do so.

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**CONTENTS** **PAGE**

**EXHIBITS** **PAGE**

Image courtesy of TTP Group plc

# 1 INTRODUCTION AND SUMMARY

**In nearly a quarter of a century of existence, the SBIR programme has played a pivotal role in exploiting the US science base and supporting the growth of its small science and technology companies. The purpose of this report is to examine how it operates and to assess its economic impact. It also looks at the relationship with the broader small business procurement "set aside" policies in the US, and at the market pull-through effect they exert on small US firms. The final section of the report makes specific and detailed recommendations on action that could be taken to replicate the SBIR programme in the UK so that government departments can participate more effectively in building the innovation based economy we need to remain competitive as a nation.**

## 1.1 How Technology Firms Get Created

The popular perception of how successful high technology companies get started is based on what is sometimes referred to as the "Silicon Valley" model. An engineer or scientist has an idea for a new product based on his invention. He starts development in his laboratory or garage with a couple of colleagues, writes a business plan and uses that to raise money from venture capitalists and other investors. This, and subsequent investments, finances the development and marketing of the firm's product.

The reality is usually rather different. In practice it is often research and development contracts placed by customers that play the key role in getting a business started and in early stage funding, not equity from investors.

A company whose funding comes mainly from R&D contracts is sometimes known as a "soft" company. Its business may be based around the founders' scientific or engineering expertise or around a piece of proprietary technology with applications in different markets. The name reflects the ability of "soft" companies to mould their strategies and R&D programmes to respond to a range of different customers' needs. "Hard" companies, focused on the development of **standard** products, have less flexible strategies. They conform more to the Silicon Valley approach to venture capitalism. They usually offer much larger rewards, but they also entail much higher investment costs and risks.

Many of the UK's successful technology companies - possibly even most - owe their origins to the "soft" company model in one way or other.[1] Cambridge Silicon Radio (CSR), probably the most successful UK technology start up of the 1990's, is a good example. Its founders had honed their CMOS wireless design expertise and management skills over 10 years within Cambridge Consultants by carrying out a wide range of development contracts for different customers. When Bluetooth emerged as an important new wireless standard, they were perfectly positioned to spin out with venture capital funding and start a "hard", product business to exploit it.

Their combined experience, and that of the substantial start up team they took with them, helped CSR succeed against competition from dozens of other Bluetooth start-ups around the world.

Besides bringing funding, paid R&D contracts from demanding customers also provide a key driver of commercial innovation. By focusing technology development on real, well defined customer needs, they provide the best market research a technology company can have.

R&D contracts perform a particularly important role in relation to platform technologies – important scientific or engineering breakthroughs with multiple potential applications. Identifying the real ones only becomes clear as a result of carrying out feasibility studies and then developing technical demonstrators or prototypes for different end users. It is new platform technologies that represent some of the most significant spin off opportunities from within the academic science base, though because of the long timescales involved in searching out, proving and developing valuable applications, they are often hard for venture capitalists and private investors to back.

For start-ups based on platform technologies, contracts with real customers, carried out within a commercial, rather than an academic environment, must play the key role during this exploratory development phase. Examples abound in sensors, imaging, materials and the life sciences as well as in more advanced areas of mathematical computing.

"Soft" companies also play another important role in the high-tech economy. They are relatively straightforward to manage, certainly much easier than "hard" companies which need a broader range of strategic, marketing and financial skills. For founders with a predominantly technical background, "soft" companies therefore provide a useful stepping stone, and often also a training ground, on the way towards a faster growth and more demanding, "hard" company model as opportunities emerge for "standard" products.

1 See *Exploiting the Science and Technology Base: How to Fill the Gaping Hole in UK Government Policy*, David Connell, TTP Ventures, 2004 for a more detailed discussion and examples. This is available from **www.cbr.cam.ac.uk**.

Even Intel owes its success today to a customer funded development. In 1970, shortage of funds and engineering resources caused it to finance development of the world's first single chip microprocessor with a $60,000 contract from the Nippon Calculating Corporation.[2] NCF's demanding technical requirements for calculator chips helped Intel's engineers come up with the design for the Intel 4004. Its business today is largely based on this product's successors. When NCF got into financial difficulties later, Intel was able to buy out NCF's rights. "I think it gave Intel its future", said Chairman Andy Grove in an interview much later, "...but for maybe the first ten years we looked at it as a sideshow".

## 1.2 Government Procurement and Innovation

Both the examples quoted above owe a large part of their success to **commercial** R&D contracts. But the **public sector** also has a need for innovative technologies. By placing R&D contracts with new technology companies, and by trialling and purchasing their products, it can also play an important role in building a high technology economy. The US government's role in nurturing the computer and semiconductor industries during the Cold War is well recognised, with the Department of Defense, NASA and National Security Agency all playing a key part.[3] There are also examples in the UK. For example, Neurodynamics, the "soft" start-up which later spun out Autonomy, had important contracts with the UK police services.

As policy makers grapple with how the UK is to compete internationally against increasingly technologically sophisticated, but still low wage cost economies such as China and India, the future role of public sector procurement in the innovation economy assumes a position of pivotal importance. The public sector represents a substantial proportion of the overall UK economy; for example, it purchases some 55% of all information technology products and services. If the UK is to meet its Lisbon Agenda target of increasing R&D spend from 1.9% to 2.5% of GDP, government procurement simply must play its full role in stimulating innovation.

But despite occasional examples, such as Neurodynamics, there is powerful evidence today to indicate that government is failing in this challenge. This comes from the frustrations of individual companies trying to secure R&D contracts from departments and from the government itself, through its repeated statements on the role it wants procurement to play in the economy. The problem appears to stem both from the perception across many government agencies that innovation is the responsibility only of the private sector and, perhaps the DTI, and from the overwhelming predominance of value for money considerations and risk minimisation in public procurement procedures.

*Innovation is essentially about solving problems. And in business, it is understanding a customer's problems and having the technologies and skills to address them that is the key to developing ground breaking new products.*

The United States does things differently; and from the strength of its high technology economy, one must judge with some success. The purpose of this report is to see what we can learn from the US experience, by examining the lead federal government policy for using R&D procurement to stimulate innovation in smaller companies – the Small Business Innovation Research (SBIR) programme. In doing so, it also looks at the relationship with the broader small business procurement "set aside" policies in the US, and at the market pull through effect they exert on small US firms.

It makes specific and detailed recommendations on action that could be taken **NOW** to enable UK government departments to participate more effectively in the innovation economy.

## 1.3 The US SBIR Programme

The SBIR programme was established in 1982 and is the world's largest seed capital programme for science and technology businesses. Each year it makes over 4,000 awards to US small businesses, totalling over $2 billion in value. It has helped thousands of US academics become entrepreneurs, and converted billions of dollars of US taxpayer-funded research into highly valuable goods and services, benefiting both society and the economy.

SBIR awards take the form not of equity, loans or grants (in the sense used in the UK), but of contracts for the development of technologies that US federal government agencies believe they require as customers, specifiers or research organisations.[4] The aim is that this will lead on to mainstream development contracts, procurement by the agency of developed products or some other form of commercialisation.

SBIR awards are designed to provide 100% of the funding needed for a project, plus a small profit element for the business undertaking it. Whilst the "norm" is $850k for each SBIR project, the size of awards can be substantially larger. Small businesses can win and run multiple projects in parallel. It is quite common for US companies to have received several million dollars, sometimes each year, from this source.

2 See *Making Silicon Valley, Innovation and Growth of High Tech*, 1930-1970, Christopher Lécuyer 2006. A transcription of the Intel/NCM agreement is available at **www.xnumber.com**.

3 See, for example *'Funding a Revolution: Government Support for Computing Research'*, National Research Council, Washington DC, 1999. *'Body of Secrets'* by James Bamford (Arrow, 2002) includes a less official, but nevertheless compelling description of the role of the National Security Agency in creating the US supercomputing industry.

4 Some SBIR awards are defined as "grants", but they provide 100% funding for directed research projects and are therefore contracts in all but name.

This is in stark contrast to UK government support for technology companies. Here the principal instrument – Development Grants provided under the DTI Grants for R&D Scheme – only provide a maximum of £200k per project, and the company concerned must be able to fund 65% of the total costs from its own resources before work can start. Grants for multiple projects are unheard of in the UK.

In the US, the legislation underpinning the SBIR programme requires that 2.5% of all federal government agencies' external R&D budgets are distributed through this programme. Each agency runs a highly efficient process for advertising topics of interest and making awards. The majority of award winners are businesses with less than 25 employees, though US businesses with up to 500 staff are eligible.

The SBIR programme's design incorporates a number of important elements that add to its effectiveness:

- Regular solicitations at fixed dates during the year;
- Awards directed at the best submissions from across the US; no state or regional quotas;
- Complete transparency in terms of topics, awards winners and amounts;
- Standard contracts;
- Discussions with agency topic managers are encouraged;
- Clear linkage to agency R&D interests and priorities; strong focus on commercialisation;
- Business ownership of the intellectual property developed;
- Companies do not have to be established until awards have been won;
- 100% funding of all contract costs plus a profit element;
- Flexible mechanisms to encourage involvement of academics and support academic spinouts and technology transfer. The closely related Small Business Technology Transfer (STTR) programme, worth a further $230m a year, is specifically for projects involving collaboration with a university;
- Phased awards to manage risk, typically with $100k for a Phase I feasibility study and 50% of Phase I award winners going on to win a $750k Phase II development award;
- Phase III SBIR awards funded from mainstream (i.e. non SBIR budgets), and adding probably as much again to overall federal R&D expenditure on SBIR derived projects;
- Phase III projects bring businesses the opportunity to win valuable sole supplier contracts with federal agencies;
- Prime contractors are encouraged to take up SBIR developed products.

The SBIR programme is just part of a panoply of policies designed to favour small US businesses through the procurement process – both directly and indirectly through the large corporations that mainly supply government agencies. It is just the first step on the procurement ladder.

**As a result of these mechanisms, US early stage technology companies have access to Government R&D funding at a level which is much larger per company – probably by an order of magnitude – than in the UK.**

**As a source of early stage finance, the SBIR programme is probably at least as important in value terms as venture capital. However, unlike most venture capital investments, SBIR awards are available from right at the start of a business's life.**

## 1.4 Other US Policies for Small Businesses: "Set Asides" and State Innovation Programmes

This report focuses on the SBIR programme. However, this cannot be considered in isolation from the United States' broader "set aside" legislation. Indeed the two are often confused.

The US has a long established and complex set of policies to favour small businesses in government procurement of all products and services. Under this programme, each agency is given annual "set aside" targets for the percentage it must spend with small US businesses. The statutory minimum target is 23%.

In addition, there are also "set aside" targets for prime contractors' expenditure with US small businesses. For example, in 2005 the Department of Defense's goal was 43%. When taken together, this means that over two fifths of Department of Defense procurement expenditure is earmarked, directly and indirectly for small US firms. These targets are carefully monitored and large US corporations have Small Business Offices to ensure they comply. There is therefore a natural pull through of products and technologies developed by small businesses under the SBIR programme and an implicit bias away from non US suppliers.

At national level, the overall percentage of R&D contracts going to small firms is also monitored. In 2003 it was 13%.

The SBIR programme is concerned with federal government agencies. Many individual US states also operate their own economic development programmes. A key element of these is normally aimed at helping local firms win federal SBIR awards, by providing small, "Phase Zero" awards to fund the preparation of proposals, sometimes also with subsidised consulting support.

Some states also offer R&D grants, rather like the DTI scheme. A full analysis of state level programmes is beyond the scope of this report, but data from some research undertaken for the State of Maine provides some useful insights. Per head of population its grants programme is more generous in all important aspects than the broadly equivalent DTI's Grants for R&D scheme. Its technology firms therefore receive better government financial support from the State **even before** the much more important federal SBIR programmes are taken into account. With other federal R&D programmes, they add a further $11 for each $1 of state support.

## 1.5 The Economic Impact of the US SBIR Programme

The SBIR programme is used by firms ranging from start-ups to companies with nearly 500 employees. It funds applications from defense electronics to healthcare. It is highly regarded across both government and industry, and in its nearly a quarter of a century of existence has been the subject of repeated favourable reviews by the Government Accountability Office (previously the General Accounting Office) of Congress. Concerns raised over the detailed operation of SBIR, for example regarding the number of awards going to "frequent winners", levels of commercialisation and the geographic concentration of awards in certain states, have not been serious enough to change this perception. Individual agencies have fine tuned their programmes to deal with these issues.

Companies that have benefited include: major corporations like Qualcomm, Amgen and Genzyme, that won SBIR awards in their early days, but moved on to grow rapidly through venture capital financing and IPO; firms like Photobit, described in Section 3, whose success with CMOS image sensors led to its acquisition by a larger publicly listed US firm; and many smaller specialised technology firms, like Embrex, which sells chick vaccination equipment and other poultry related technology, which is described in Section 6.

**One academic study has shown that over a 10 year period, SBIR funded companies generated five times as many new jobs as non-SBIR funded firms. Over 300 SBIR award winners now have public market listings.**

## 1.6 Potential Benefits of a UK SBIR Programme

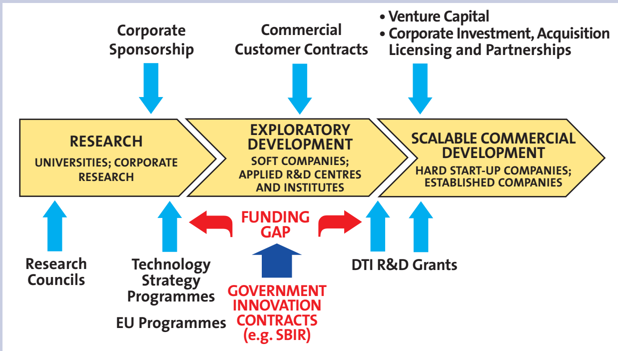
The existence of a "funding gap" for early stage UK technology companies has been highlighted at depressingly regular intervals over past decades.[5] However the problem remains unsolved. And despite the successes of a very few specialist venture capital firms, the average financial returns generated by this part of the UK private equity industry have shown such poor performance, and over such a sustained period of time, that very few institutional investors now have a serious appetite for the asset class.

The problems experienced by early stage venture capital firms are mirrored by individual "angel" investors. Existing UK grant programmes do little to help and are unavailable unless private sector funding is already in place. Indeed, the very persistence of the problem suggests that we must look for other solutions if we are to address it successfully. R&D contracts, from both the private and public sector can play a major role.

A UK initiative similar to the US SBIR programme would benefit the economy in many different ways:

- It would stimulate innovation in public sector services, and help address policy challenges in areas like healthcare, energy, transport and environment;
- It would provide a method of financing start-ups which addresses key funding gaps, with major practical benefits to potential entrepreneurs throughout the UK;
- It would facilitate spin-outs and technology transfer from universities by providing a flexible approach for funding the transfer of people into the commercial world;
- It would provide validation of new technologies, helping firms to win the support of further customers as well as partners and investors;
- It would reduce time to market by facilitating early development and trials with lead customers;
- It would make it easier for small companies to access **mainstream** government procurement budgets;
- It would increase the number of "venture capital ready" companies, leading both to a stronger technology sector and to a healthy and growing venture capital industry to finance it.

**EXHIBIT 1.1: STAGES IN THE COMMERCIAL EXPLOITATION OF NEW SCIENCE AND TECHNOLOGY PLATFORMS AND UK FUNDING MECHANISMS**




5 The gap in funding is frequently referred to as an 'equity gap', a term which incorporates an implicit but unjustified assumption, in the view of the author, about the kind of funding needed at this stage in the development of a new technology business.

## 1.7 What the UK Should Do

In an attempt to emulate the US SBIR programme, the UK government introduced a similarly named initiative in 2001. Called the "Small Business Research Initiative" (SBRI), it provided a web portal through which government departments could advertise R&D contracts. The objective was for 2.5% of external R&D to be spent with small and medium-sized enterprises (SMEs) through this mechanism. However, up to 2005, it only ever advertised contracts totalling around £2m per year, and virtually no departments participated.

In March 2005, Gordon Brown announced that the SBRI's 2.5% target was to become mandatory.[6] However, subsequent attempts by the Small Business Service to improve the SBRI have achieved little. It still bears little or no resemblance to the US SBIR programme it purports to imitate.

To implement an effective US-style programme in the UK, it is necessary to address three important issues:

(i) It must encourage individual government departments to identify areas where they need innovative new technology to meet their objectives and to commission R&D contracts to develop and trial this technology. This will involve an important change in culture, and a new approach to R&D for many departments;

(ii) It must enable officials to do this efficiently without falling foul of "value-for-money" dominated Office of Government Commerce procurement rules designed for conventional products and services, and which inhibit risk taking;

(iii) It must not conflict with EU regulations on procurement and state aids which would make a simple transposition of US legislation impossible.

Section 8 of this report proposes an approach which addresses these issues. It would enable a US style programme to be introduced **now** without breaching EU regulations.

The approach would involve the provision of £100m a year for "innovation contracts" awarded by departments on a similar basis to the US SBIR programme. Each contract would be worth up to £500k.

The details are based on work undertaken by the author with Anne Campbell (ex MP for Cambridge) and Kitty Ussher MP for their private members' bills. The approach proposed does not demand a legislative approach, though it will undoubtedly need initially to be driven from the top of government if conflicts between departmental objectives,

Image courtesy of UK Science Park Association

and the cultural barriers to innovation and risk taking within them, are to be overcome.

The major economic challenge for UK policy makers in the early part of the 21st century is to find a way of sustaining a high wage economy against competition from low cost, but increasingly technologically sophisticated, nations like China and India on the one hand, and from US based companies benefiting from its enormous R&D investments and the overwhelming dominance of its market for science and technology based products on the other. It is essential that the UK public sector plays its full role in the 21st century "innovation economy" we will need to create.

The US is the world's most successful economy at building science and technology based industries and its use of procurement, through the SBIR programme and other mechanisms, has played a key part in that success. We would do well to learn from its experience.

*"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. 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".*

Dr Eric Fossum, founder of Photobit Technology Corporation.

*"We would all have preferred to establish the company in Cambridge, rather than California, because Cambridge is where the research and development has taken place. But the funding gap for start-up biotech companies in the UK is such that we did not have a choice".*

Dr Helen Lee, Cambridge University academic, founder of Diagnostics for the Real World and serial SBIR award winner.

6 This followed a campaign led by the author and Anne Campbell, then MP for Cambridge.

# 2 WHAT AMERICA'S SBIR PROGRAMME DOES - AN OVERVIEW

## 2.1 How and Why SBIR was Established

**The Small Business Innovation Research programme was established in 1982 when legislation was signed by President Ronald Reagan requiring all larger US Federal Government Agencies[7] to "set aside" a small proportion of their annual external R&D budgets to be spent with small businesses.[8] It followed an earlier "pilot" programme initiated by the National Science Foundation.**

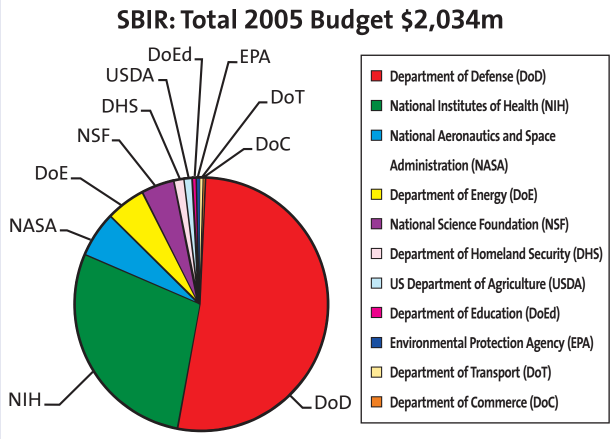
The 1982 legislation was passed against strong opposition from universities, the Department of Defense and other government agencies who were concerned about losing control over a portion of their budgets. Campaigners for the programme argued that while small businesses generated 50% of the new jobs created every year, they received only 3% of federal R&D funds, so that a shift in the balance would bring important economic benefits to the nation. In the end, US government support for the Bill was only achieved partly as a result of a trade off in return for political support for other government legislation.

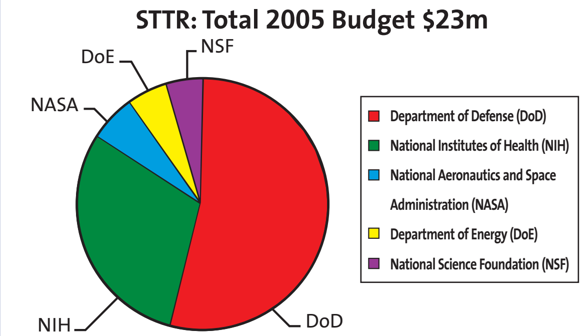
Between 1982 and 1988 the SBIR "set aside" grew from 0.2% to 1.25%, and the SBIR programme has gained increasing support from across government, as well as from the small business, venture capital and research communities. When it was re-authorised in 1992, the percentage "set aside" was increased again to 2.5% and greater emphasis was put on the commercialisation of SBIR-funded technologies. In addition, a closely related programme to support similar projects undertaken in collaboration with universities – the Small Business Technology Transfer programme – was created alongside it, with a further 0.15% "set aside" from external R&D budgets.

In 2001, the SBIR programme was extended to 2008, while the STTR programme has been extended to 2009 and the "set aside" increased to 0.3%. This gives a total SBIR/STTR "set aside" today of 2.8% for larger agencies. The SBIR programme is intended to help the US meet four major goals. These were designated by Congress in 1982 and have remained unchanged since. They are:

- to stimulate technological innovation;
- to use small businesses to meet federal R&D needs;
- to foster and encourage participation in technological innovation by minorities and disadvantaged persons;
- to increase private-sector commercialisation of innovations derived from federal R&D.

**EXHIBIT 2.1: FEDERAL AGENCIES PARTICIPATING IN THE SBIR AND STTR PROGRAMMES**




## 2.2 How the SBIR Programme is Enshrined in Law

The legislation underpinning the SBIR programme incorporates seven important elements:

(i) Agencies must regularly advertise the areas in which they wish to fund R&D programmes in support of their agency missions and requirements;

(ii) Awards are made to small businesses submitting proposals on a competitive basis;

(iii) Projects are awarded funds in three phases;
- Phase 1, for a feasibility study, typically lasting 6 months and costing up to $100k per project;

7 SBIR participating agencies are those with external R&D budgets greater than $100m per annum.

8 Small Business Innovation Research Development Act, 1982.

- Phase II, for the development stage, generally leading to a prototype or demonstrator, worth up to $750k[9] per project and typically lasting 2 years;
- Phase III; further funding from federal government sources for follow on development or commercialisation; Phase III funding comes from outside the 2.5% SBIR and 0.3% STTR "set asides";

(iv) Companies can apply for, and win, multiple awards from different agencies providing they are not for the same project;

(v) Funding is designed to cover 100% of project costs with an allowance for a "profit" of 7% on total costs;

(vi) The intellectual property developed during the project remains the property of the company. The government has only very limited rights for its own use, and does not receive a royalty or any form of repayment on successful commercialisation.

(vii) Projects funded through a Phase I and Phase II SBIR programme carry very valuable contractual rights once they move to Phase III; these include a preference that any future follow-on procurement should be sourced solely from the company undertaking the project.

**EXHIBIT 2.2: PRINCIPAL SBIR SOLICITATIONS FOR APPLICATION DURING 2005**

| *PROGRAMME* | *RELEASE DATE* | *CLOSING DATE* |
|---|---|---|
| • NSF SBIR/STTR<br>Topics: Biotechnology, Chemical-Based Technologies, and Emerging Opportunities | 17 August 2005 | 8 December 20 |
| • Department of Energy (SBIR/STTR) | 21 September 2005 | 2 December 2005 |
| • DHSS (NIH, CDC, FDA) SBIR | 14 Jan 2005 | 1 Apr 2005, 1 Aug 2005, 1 Dec 2005 |
| • 2006 PHS SBIR – NIH/CDC | 3 Aug 2005 | 4 Nov 2005 |
| • DHHS – NIH (SBIR/STTR)<br>Topics: Systems and Methods for Small Animal Imaging | 18 Nov 2002 | 1 Apr, 1 Aug, 1 Dec |
| • DHHS/NIH – NCI (SBIR/STTR)<br>Topics: Innovative Technologies for Molecular Analysis of Cancer | 16 Dec 2004 | 17 Feb 2005, 15 Jun 2005, 18 Oct 2005 |
| • DHHS/NIH – NCI (SBIR/STTR)<br>Innovation in Cancer Sample Preparation | 16 Dec 2004 | 17 Feb 2005, 17 Jun 2005, 18 Oct 2005 |
| • DHHS/NIH – NCI (SBIR/STTR)<br>Topics: Application of Emerging Technologies for Cancer Research | 16 Dec 2004 | 17 Feb 2005, 17 Jun 2005, 18 Oct 2005 |
| • DoD SBIR 2005.3 | 1 Aug 2005 | 14 Oct 2005 |
| • DHHS/NIH – NCI (SBIR/STTR)<br>Topics: Circulating Cells and DNA in Cancer Detection | 9 Jun 2004 | 14 Feb 2005, 13 Jun 2005, 12 Oct 2005 |
| • NASA SBIR and STTR | 7 Jul 2005 | 7 Sep 2005 |
| • USDA SBIR 2006 | 2 Jun 2005 | 1 Sep 2005 |
| • Homeland Security SBIR 2005.2 | 30 Jun 2005 | 29 Aug 2005 |
| • E-learning for HAZMAT and Emergency Response (SBIR/STTR) | 9 Jun 2005 | 18 Aug 2005 |
| • DHHS/NIH – NIAID (SBIR/STTR)<br>Topics: Small Business Biodefense Program | 15 Aug 2002 | 1 Apr, 1 Aug, 1 Dec |
| • DHHS – NIH (SBIR)<br>Topics: Bioengineering Nanotechnology Initiative | 2 Jul 2002 | 1 Apr, 1 Aug, 1 Dec |
| • DHHS – NIH (SBIR/STTR)<br>Topics: Novel Technologies for in Vivo Imaging | 19 Apr 2004 | 1 Apr, 1 Aug, 1 Dec |
| • DHHS/NIH – NIAAA (SBIR/STTR)<br>Topics: Genomic, Proteomic, and Metabolomic Fingerprints as Alcohol Biomarkers | 23 mar 2005 | 15 Jul 2005 |
| • DoD SBIR 2005.2 | 2 May 2005 | 15 Jul 2005 |
| • Dept. of Education (SBIR) | 10 Mar 2005 | 10 Jun 2005 |
| • NSF FY 06 SBIR/STTR<br>Topics: Electronics and Security Technologies | 11 Feb 2005 | 8 Jun 2005 |
| • Environmental Protection Agency SBIR | 24 Mar 2005 | 25 May 2005 |
| • Department of Transportation SBIR | 28 Feb 2005 | 16 May 2005 |
| • DoD STTR 2005 | 1 Feb 2005 | 15 Apr 2005 |
| • DHHS – NIH (SBIR/STTR)<br>Topics: Structural Biology of Membrane Proteins | 16 May 2002 | 1 Apr, 1 Aug, 1 Dec |
| • Dept. of Homeland Security SBIR | 20 Dec 2004 | 22 Feb 2005 |
| • DoC – NIST (SBIR) | 5 Nov 2004 | 28 Jan 2005 |
| • DHHS – NIH (SBIR/STTR)<br>Topics: Innovative Technologies for Enhancing Functions for Individuals with Disabilities | 4 Mar 2002 | 1 Apr, 1 Aug, 1 Dec |
| • DHHS – NIH (SBIR)<br>Topics: Improving Measurement Tools for Sternal Skin Conductance and Hot Flushes | 29 Sep 2004 | 25 Jan 2005 |
| • DoC – NOUAA (SBIR) | 20 Oct 2004 | 19 Jan 2005 |
| • DoD SBIR 2005.1 | 1 Nov 2004 | 14 Jan 2005 |
| • DHHS-NIH SBIR/STTR (Grants)<br>Topics: (AIDS and AIDS-related SBIR/STTR Grant Applications) | 9 Jan 2004 | 1 May 2004, 1 Sep 2004, 2 Jan 2005 |

Source: www.sbirworld.com/solicitations

9 The size of SBIR awards was increased to $100k for Phase I and $750k for Phase II when the SBIR programme was re-authorised in 1992. These 'standards' are currently being reviewed by the US Small Business Administration.

The sizes of Phase I and Phase II awards indicated above essentially represent the "standard" SBIR model. However, between the various government agencies there is a good deal of variation in the size of awards made, and indeed in other aspects of the SBIR programmes. In 2004, 37 Phase II awards were for over $1m, and 14 were for over $2m. Most of these larger awards emanated from the National Institutes of Health (NIH) and the Department of Defense (DoD), and both these agencies have significant scope to augment SBIR funding from mainstream agency R&D programmes. The two highest awards in 2004, each for nearly $6m, were healthcare awards that went to SIGA Technologies to take antiviral treatments against bioterrorism pathogens through FDA approvals. Other important differences in approach between agencies are summarised in Section 2.4.

To be eligible for an SBIR or STTR award a company must be an "organised for profit" US business which is owned at least 51% by US citizens (or legally admitted permanent resident aliens), or at least 51% owned by another "for profit" business, that is itself at least 51% owned and controlled by one or more individuals.[10] It and its parent company must have no more than 500 employees.

Eligibility is judged at the time of the award, not the proposal. This makes the SBIR programme ideal for start-up situations where the founders can only afford to start the business after some initial funding has been received. However, more established small businesses also make much use of SBIR awards.

All the R&D funded by SBIR and STTR awards must be undertaken in the United States, though a proportion (up to 1/3 of Phase I and 1/2 of Phase II) may be performed outside the small business concerned.[11]

The "Principal Investigator" or project leader of an SBIR project must be at least 51% employed by the firm during the period of the award, which means that SBIR projects provide an excellent vehicle for transitioning technology developed in a university or research institution to a commercial business.

## 2.3 What Kinds of Companies Win SBIR Awards

Firms carrying out SBIR projects tend to be at the smaller end of the "small business" spectrum. For example, roughly 70% of Department of Defense SBIR awards go to companies employing fewer than 25 people. This is probably partly due to the importance of small businesses in innovation, and partly due to the fact that, once companies have built up their capabilities and developed their track records, there are much larger R&D contracts available to them from mainstream federal R&D budgets.

About a third of Phase I awardees each year are first-time winners. However, many companies receive several million dollars a year from SBIR and related agency programmes, and companies that win multiple awards are common.

At the far end of the scale is what is often referred to as "Frequent Award Winners" or SBIR "mills". A review of the SBIR programme in 1999 found that about 11 per cent of all awards between 1983 and 1997 had gone to just 25 companies. The most successful of these was Foster-Miller, a Boston-based engineering and technology development firm founded by three MIT graduates to solve difficult technical problems for clients. By 1997 Foster-Miller had won 573 SBIR and STTR awards, including 147 Phase II awards. In total these were worth $108m in revenue to the company and in 1998 they represented 20% of its annual sales.[12]

The next most successful Frequent Award Winner, with 377 awards, was Physical Optics Corporation, a Los Angeles based company involved in optoelectronics components and systems. Some 68% of its total revenues came from SBIR awards in 1998.

Foster-Miller was sold to QinetiQ in September 2004, by which time its SBIR tally is believed to have totalled over $200m.[13] In 2003, its last full year of independent ownership, it won 62 SBIR and STTR Phase I and Phase II awards with a total value of $15.6m. These were mainly from the DoD, but awards were also received from the Department of Transport, Environmental Protection Agency, Department of Energy, NASA and the National Institutes of Health.

There has been continued debate over whether frequent award winners are being allowed to abuse the system and, partly as a result, evidence of commercialisation planning and track record is now increasingly used as a criterion for making SBIR awards. However, some argue that these companies win so many awards precisely because they are very efficient at carrying out specialised R&D on behalf of the government. And on balance, their existence has not been considered sufficiently worrying to undermine the overall value of the programme.

In contrast, after winning one or two early awards, some SBIR award winners, rather than continuing to apply for further government R&D contracts, move on rapidly to raise venture capital to finance technology development and make the difficult transition to a commercial business. At this point they move outside the visible range of the SBIR community.

Of 15,000 SBIR awardees since 1983, 323 are publicly traded on NASDAQ or another US stock market.[14] Three of the most successful past SBIR recipients are listed in Exhibit 2.3.

10 Until 2004, SBIR awards were frequently made to companies which were majority owned by one or more venture capital funds. However, a recent Small Business Administration ruling currently excludes such businesses. The precise situation on eligibility is the subject of debate, and it is possible that the historic practice will be re-established.

11 The author is aware of one UK start up which raised funding from US investors and has gone on to win an SBIR award on the basis that it WILL BE establishing a US laboratory to undertake it.

12 Evidence to House of Representatives Committee on Science June 17th 1999, Susan D. Kladiva. See also *Evaluation of Small Business Innovation Research Can Be Strengthened*, United States General Accounting Office Report to the Committee on Science, House of Representatives, June 1999.

13 At the time of its acquisition by QinetiQ, Foster-Miller's SBIR business was reportedly sold off to InfoSciTex Corporation, as Foster-Miller no longer qualified for small business status. However, it is to be presumed that QinetiQ will continue to benefit from the favourable status of any Phase III contracts derived from its earlier SBIR awards.

14 Source: *InKnowvation SBIR Index*. This figure excludes companies traded on illiquid, 'junior' markets.

**EXHIBIT 2.3: SOME OF THE MOST SUCCESSFUL PAST SBIR RECIPIENTS**

| Company | Business | Start Date | Number of Employees | Annual Revenues | Market Capitalisation |
|---|---|---|---|---|---|
| *Qualcomm* | Mobile Phone Technology | 1985 | 9,000 | $6.6 billion | $78 billion |
| *Amgen* | Biotechnology based Pharmaceuticals | 1980 | 14,000 | $12 billion | $93 billion |
| *Genzyme* | Biotechnology based Pharmaceuticals and Genetic Testing Services | 1981 | 8,000 | $2.6 billion | $18 billion |

So it is perhaps not surprising that Congress reached the following, highly positive, conclusions when, in 1999, it had to decide whether or not to renew the SBIR programme:

*(1) the small business innovation research program established under the Small Business Innovation Development Act of 1982 and reauthorised by the Small Business Research and Development Enhancement Act of 1992 is highly successful in involving small businesses in federally funded research and development;*

*(2) the SBIR program made the cost-effective and unique research and development capabilities possessed by the small businesses of this Nation available to Federal agencies and departments;*

*(3) the innovative goods and services developed by small businesses that participated in the SBIR program have produced innovations of critical importance in a wide variety of high-technology fields, including biology, medicine, education and defense;*

*(4) the SBIR program is a catalyst in the promotion of research and development, the commercialisation of innovative technology, the development of new products and services, and the continued excellence of this Nation's high technology industries; and*

*(5) the continuation of the SBIR program will provide expanded opportunities for one of the Nation's vital resources, its small businesses, will foster invention, research, and technology, will create jobs, and will increase this Nation's competitiveness in international markets.*[15]

## 2.4 How Participating Agencies Administer SBIR Funding

The largest SBIR funding agencies are the Department of Defense (responsible for about half the overall total) and the National Institutes of Health. The full breakdown is shown in Exhibit 2.4, which also highlights key differences in the approaches of individual agencies.

**EXHIBIT 2.4: DIFFERENCES BETWEEN AGENCY SBIR PROGRAMMES**

| | DOD | NASA | DOT | EPA | DOE | DHS | DOC | NSF | USDA | DoEd | NIH |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *2005 SBIR Budget ($m)* | 1080 | 110 | 4 | 7 | 101 | 23 | 4 | 94 | 19 | 10 | 582 |
| *Research Topics* | S | S | S | S | S | S | S | B | B | S | B |
| *Award Type (Contract/Grant)* | C | C | C | C | G | C | C | G | G | G/C | G/C |
| *Award Amount Phase I ($)* | 70k-100k(a) | 70k SBIR 100k STTR | 100k | 70k | 100k 9 months | 100k | 75k | 100k | 80k | 100k | 100k(b) |
| *Award Amount Phase II ($)* | 750k | 600k | 720k | 225k(c) | 750k | TBD | 300k | 500k(c) | 325k | 750k | 760k(b) |
| *Gap Funding* | Y | N | N | N | Y | N | N | Y | Y | N | Y |
| *Review Process* | I | I | I | I | E | I | I | E | E | I | E |
| *Communication* | R | R | R | R | R | R | R | O | O | O | O |

**KEY:**

S - Specific
B - Broad
C - Contracts
G - Grants
I - Internal Review
E - External Review
R - Restricted
O - Open

a - Varies among DOD Companies
b - Deviations permitted with justification
c - Some agencies offer Phase II Options

DoD - Department of Defense
NASA - National Aeronautical and Space Administration
DoT - Department of Transport
EPA - Environmental Protection Agency
DoE - Department of Energy
DHS - Department of Homeland Security
DoC - Department of Commerce
NSF - National Science Foundation
USDA - United States Department of Agriculture
DoEd - Department of Education
NIH - National Institutes of Health

Source: Presentation by Joe Henebury (DOT) Steve Gullfoss (Air Force) and Jo Anne Goodnight (NIH) at National SBIR Conference, Albany, November 2005

15 106th Congress, House of Representatives, Report of the Committee on Small Business – September 23rd 1999.

## Definition of Research Topics and Types of Award

Some agencies, such as the Department of Defense, define SBIR topics in great detail; others, such as the United States Department of Agriculture (USDA), indicate much broader areas of interest and invite applicants to define both the problem and the proposed solution.

Agencies that have very precise requirements linked to their own operations and internal development programmes (such as NASA) tend to define awards as "contracts". Those whose role is itself "research", such as the National Institutes of Health (NIH), or whose requirements for new technology, like USDA, are rather broad, tend to describe awards as "grants". It should be noted, however, that these are very different to the kinds of government grants with which businesses are familiar in the UK - not least because they require no matched funding. These are grants for "directed research". In many cases, for example NIH topics, the requirements and deliverables are defined in great detail in the specification. The release of funding through Phase I, Phase II and beyond depends on progress against defined milestones. From a UK perspective, we would regard SBIR "grants" as R&D contracts in all but words.

## Amount and Phasing of Funding

As previously mentioned, the $100k Phase I and $750k Phase II "standard" is not adhered to precisely by all agencies. The National Institutes of Health regularly fund much larger Phase II awards, and indeed actively encourage applicants to make "realistic" bids. They also offer "Competing Continuation Awards", typically worth up to $3m over 3 years, to fund pre-clinical trials.

Many agencies have split the "standard" funding packages to try to bridge the time gap between "Phase I" and "Phase II".

There is no Phase III funding within agencies' SBIR budgets. However, they do have the capacity to fund beyond Phase II through their non-SBIR budgets. Some agencies will extend Phase II funding beyond the standard $750k where matched funding is available from another source. This can come from the same agency's mainstream (i.e. non-SBIR) R&D budget, or from another agency, or from private sector sources.

Data on the amounts and frequency of Phase III funding are more difficult to establish than for Phases I and II. However, data from the US Navy shows that each $100 spent from its SBIR budget attracts a further $159 in follow-on Phase III Navy funding, plus $52 in Phase III funding from other parts of the Department of Defense.

Details of the approaches adopted by a selection of individual agencies are provided in Sections 3 to 6.

## Solicitation and Award Process

One of the most important features of the SBIR programme is the transparency of the solicitation and award process. All agencies keep to the principles defined by the SBIR legislation; rules, timetables and awards are published in great detail on agency websites, a list of which is provided in the Appendix. However, each agency has its own review and selection process. Some use internal reviewers, others use external reviewers. Some use a combination of the two. Reviewers' comments are normally available to applicants, but the precise arrangements differ between agencies. Success rates, particularly for moving from Phase I to Phase II, vary from agency to agency.

Agency SBIR Programme Managers are typically strong enthusiasts and excellent communicators who have been working with their agency for many years. They are very active in promoting their programmes to the business and research communities. The Agency Technical Officers, the individuals responsible for developing and managing individual topics and projects, are also very accessible. Companies interested in participating in the SBIR programme are encouraged to get to know them in advance to understand their R&D interests and requirements, and to influence their ideas.

This report examines the detailed workings of four of these agencies: the two largest, namely the Department of Defense and the National Institutes of Health; the National Science Foundation, whose role is broadly similar to that of the UK Research Councils; and the US Department of Agriculture, an agency with one of the smaller SBIR budgets.

## 2.5 Relationship with Broader US Small Business "Set Aside" Policy

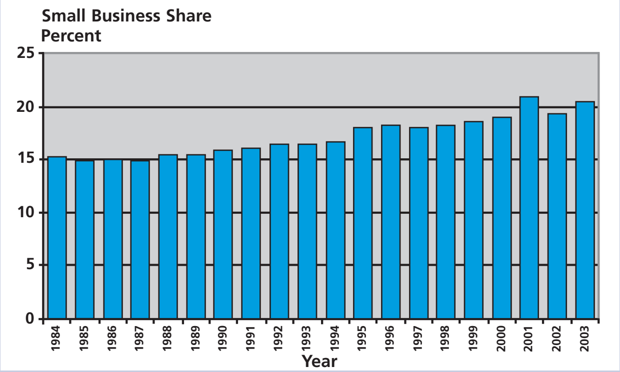
The SBIR and STTR programmes are just part of a long established, and much broader, set of US policies designed to favour small US businesses in government procurement.[16] All federal agencies are given annual goals for the percentage of overall procurement expenditure that is to be spent with small businesses.[17] The statutory minimum target is 23%. By 2003, the percentage of federal procurement expenditure going **directly** to small businesses[18] was around 21%, having increased steadily from around 15% in the 1980s. On top of these targets for direct expenditure, there are also small business "set aside" targets for subcontract procurement by prime contractors.

16 For mainstream procurement (but not SBIR) purposes, the definition of "small business" depends on the type of business it is engaged in. For example, the size limit for electronic businesses is 500 employees; for computers it is 1,000 employees and for aircraft, 1,500: *Small Business Specialist Guide*, US Air Force February 2006.

17 Within the overall small business target, there are also targets for Small Disadvantaged Businesses, Women Owned Small Businesses, Veteran Owned Small Businesses and Service Disabled Veteran Owned Small Businesses.

18 The US generally defines a small business as one employing less than 500 people (though see Note 16 above). This compares with the UK and EU definition of small and medium sized businesses (SME's) which is businesses with less than 250 employees. It is unlikely that this difference in definition has a major impact on the argument.

**EXHIBIT 2.5: PROPORTION OF US FEDERAL GOVERNMENT CONTRACTS AWARDED TO SMALL BUSINESSES SINCE 1984**




Figures relate to all federal government contract actions over $25,000. See Note [19] below.

The precise targets for direct and prime contractor expenditure with small firms vary from agency to agency and from year to year. The Department of Defense's 2005 goals were 23% and 43% respectively.[20] **When looked at in combination this means that over two fifths of its procurement expenditure is directed by law towards small US companies.**

Achievement against these targets is monitored annually and agencies in turn monitor the "set aside" performance of their prime contractors – typically quarterly. So, for example, when Boeing or Raytheon is awarded a contract to develop or supply new technology, equipment or services, the contract includes an agreed plan showing how the targets for the percentage of the work to be sub-contracted to small businesses are to be met. The quality of this plan may affect whether they win the contract. They must also submit regular reports, showing their actual performance in small business sub-contracting against these targets.

When it comes to **R&D contracts**, not just those awarded under the SBIR and STTR programmes, American small businesses again appear to be benefiting significantly from the "set aside" legislation and philosophy. Across US federal government, as a whole, small businesses were awarded $5 billion in R&D contracts in 2003, representing a 13% share of the total value of all R&D contracts worth more than $25,000.[21] These figures exclude that portion of SBIR awards, and awards under other programmes, which are defined as "grants".

In the case of Department of Defense contracts, the level of sub-contracting is routinely monitored by the Defense Contract Management Agency. Large businesses that have received at least one Department of Defense contract in excess of

**EXHIBIT 2.6: VALUE OF CONTRACTS AWARDED BY DoD IN 2003 AND PROPORTION SUB-CONTRACTED BY PRIME CONTRACTORS TO US SMALL BUSINESSES**

| *By Service* | *Army* | *Navy* | *Air Force* | *DCMA* | *PENREN* | *DESC* | *TOTAL* |
|---|---|---|---|---|---|---|---|
| Number of Prime Contractors | 456 | 397 | 123 | 958 | 48 | 13 | 1,995 |
| Total Business Contracts ($m) | 5,183 | 7,359 | 854 | 72,690 | 399 | 16 | 86,505 |
| Value of Work Sub-contracted to Small Business ($m) | 2,591 | 3,150 | 392 | 25,737 | 120 | 11 | 32,004 |
| % | 50.0 | 42.8 | 45.9 | 35.4 | 30.2 | 65.9 | 37.0 |

**KEY:** DCMA is the Defense Contract Management Agency
DESC is the Defense Energy Supply Center
PENREN is the Pentagon Renovation and Construction Program

| *By Five Largest Prime Contractor/Supplier Reporting Centres* | | | | | |
|---|---|---|---|---|---|
| *Company* | *Boeing Company* | *Chevron USA Inc* | *Raytheon Company* | *Lockheed Martin Aeronautics Co* | *Minnesota Mining & Manufacturing Co* |
| Location | Chicago | San Ramon | Waltham | Fort Worth | St Paul |
| Total Contracts ($m) | 11,030 | 4,832 | 4,170 | 3,906 | 3,756 |
| Sub-contracted to Small Business ($m) | 2,263 | 1,310 | 1,688 | 844 | 1,531 |
| % | 20.5 | 27.1 | 40.5 | 21.6 | 40.8 |

* **Note: Figures relate to largest business unit only. Some prime contractors report on multiple business units, separately. Source: Defense Contract Management Agency.**

19 The Small Business Economy, a Report to the President, Small Business Agency 2004.

20 According to the Department of Defense Office of Small Business Programs, in 2004, out of a total procurement budget of $194 billion, the DoD placed 23.1%, worth $44.8 billion, directly with small businesses. Its prime contractors incurred a total of $101.8 billion subcontract expenditure with their own suppliers, of which $35.2 billion was with small businesses. So in total, $80 billion, or 41.2%, of the DoD's annual procurement expenditure was directed to small US businesses through the small business set aside programme.

21 The Small Business Economy; Op.Cit.

$500,000 are required by law to establish a small business sub-contracting programme, and to report twice a year to the Department of Defense on small business sub-contracting performance. Recent figures for each of the main arms of the DoD, together with those for the five largest US defense contractor reporting centres are shown in Exhibit 2.6.

Besides exerting leverage on suppliers and prime contractors in this way, the Department of Defense also operates a variety of initiatives through the Office of Small Business Programs to help small businesses find and secure contracts and sub-contracts.

As a result of these measures all large US contractors maintain some form of "Supplier Diversity" or Small Business Office to help them search out and engage with small businesses to help them meet their sub-contracting set aside targets. Many, like Boeing and the defence company Northrop Grumman for example, also have SBIR Officers to help them find component technologies under development which could ultimately be brought into their system level products. By working with small companies at an early stage they can of course also help their subcontractors secure DoD SBIR funding for innovative component level technologies for which they see a system requirement.[22]

## 2.6 Phase III SBIR Funding and How it Makes Award Winners Attractive to Larger Corporations[23]

Anyone first examining the SBIR programme is inevitably puzzled by the concept of an unfunded Phase III.

Whilst the SBIR programme itself provides no Phase III funding, projects that have been funded with Phase I or Phase II awards from either the SBIR or STTR programmes are deemed to have achieved Phase III status if they have obtained further funding from federal government sources.

Phase III status is available for activities that:

- Commercialise applications of SBIR work;
- Involve the sale of SBIR derived products or services intended for use by the federal government, which have been or are being funded with non SBIR sources of federal funds;
- Involve continuation of research and development that derives from, extends or logically concludes that firm's prior SBIR work and has been, or will be, funded with non-SBIR funds.

Achieving Phase III status for a project imparts significant benefits to the recipient because no further competition is required in receiving further R&D funding or contracts for the supply of products or services based on it.

Agencies can "sole source" government contracts to a company that has achieved Phase III status for the technologies or products involved. Indeed it is Congress' intention that they should do so. Exceptions require prior reporting to the Small Business Agency (SBA). There is no limit on the type, number, value or duration of Phase III agreements, or on the number of agencies. A company that receives an SBIR award from Agency A is eligible in due course to obtain Phase III status from agencies B, C and D. There is also no time limit between completion of Phase II and the commencement of a Phase III contract.

As important, a small company that achieves Phase III status maintains that status even if it supplies its product through a prime contractor. So in the case of the Department of Defense a small company may supply any technology and products derived from the relevant SBIR award through, say, Boeing, Raytheon or any other systems integrator. And in the case of a company that has had technology funded by the National Institutes of Health (part of the Department of Health and Human Services (HHS)), it may ultimately supply products or services to the Department of Veterans Affairs, which is the largest buyer of health-related services and products in the US. In both cases the sole supplier preference that comes with Phase III status is maintained.

Not only is sole supplier preference maintained when a small business supplies the government through a sub-contractor, it is also maintained if the business is sold to a larger company. Its acquirer can continue to operate a sole supplier contract with the US government, and it is expected that any further contracts based on the SBIR funded technology it has acquired will be treated likewise. Sole supplier contracts are almost inevitably higher margin contracts. So there is a great incentive for large companies that wish to do business with government to monitor, support and then acquire small companies that have developed new technology under the SBIR programme.

When QinetiQ bought Foster-Miller in 2004, it can be presumed also to have acquired sole supplier status for many technologies developed for the US Government under the hundreds of the SBIR contracts awarded to it since the programme began in 1982.

## 2.7 The Relationship Between the Federal SBIR Programme and State Economic Development Policies

Unlike the UK Department of Trade and Industry Grants for Research and Development initiative which is now administered at Regional Development Agency level, each with its own budget allocation, the SBIR programme is a purely federal programme. It is designed to search out the best projects and technologies nationwide, and there are no state or regional quotas.

22 The active engagement between large and small businesses is most evident in the defense sector. But it is also evident elsewhere in US industry. 3m, a company with a diverse range of interests, including defense, says of its US Supplier Diversity Initiative that it is "committed to aggressively identify small, minority owned and women-owned sources for the goods and services 3m needs". In 2004 3m sourced 34% of sub-contracted business from US small businesses. Baxter, the US based healthcare multinational, seems to have found it more challenging to meet its supplier diversity goals. Its 2003 sub-contracting plan featured a 20% target with US and Puerto Rican small businesses.

23 This section draws heavily on a presentation by, and discussions with, David Metzger, a partner with Holland and Knight LLP and a leading expert on the US SBIR programme. Metzger has been involved with the SBIR programme since its inception when he was working at the Small Business Administration.

Not surprisingly, companies in California and Massachusetts, the two centres of US high technology, receive a high proportion of all SBIR awards – in 2004, roughly a third of the total nationally. The fact that they do so illustrates one of the challenges for any national innovation programme such as SBIR: namely, how to ensure that it funds the best technologies and companies in the country whilst dealing with legitimate political pressures from less economically advanced regions for state quotas or preferences.

The US has dealt with the regional policy conundrum by leaving it to individual states to do what they can to help their companies win SBIR awards and by developing their regional technological base, for example, by investing in universities and research institutes. The pursuit of national excellence, which is an explicit part of the SBIR process, is not compromised.

All US states have their own economic development policies and ensuring that their high technology companies win as many SBIR programmes as possible is a key element.[24]

The State of Maine, a small maritime state on the East Coast with a population of 1.3 million, provides an illuminating example of what individual states can do in order to help their local companies compete for and win the nationally-administered SBIR awards. In terms of per capita income, it is ranked 29th out of all US States. So it might be taken to be broadly representative of averagely wealthy US states.

Maine's principal economic development programmes for science and technology companies are run by the Maine Technology Institute (MTI) and are as follows:

### • SBIR/STTR Phase "O" Assistance

Cash grants of up to $5k are provided to help companies prepare Phase I and Phase II SBIR proposals. Companies must provide matching funding.

Up to three Phase "O" grants may be made per company per year.

### • Seed Grants

Cash Grants of up to $10k per project are available on a competitive basis to support early stage activities in product development, commercialisation or business planning. Again matching funding is required.

Awards are made three times a year. No single technology can normally receive seed grants totalling more than $25k.

### • Development Awards

Maine provides awards of up to $500k for R&D or related market research and business planning work for "near to market" (commercialisation within 3 years) proposals or up to $250k for "far to market" proposals. Again, matching funding is required. This scheme is actually broadly similar to the DTI Development Grant in the UK.[25] In the UK case, the company receiving the grant must normally provide 65% of total project costs and the DTI contribution is limited to £200k.

Image courtesy of Holdsworth Associates and Owlstone Ltd

### • Accelerated Commercialisation Fund

This is a small investment fund for matching private sector investments, for example by venture capital firms, in companies exploiting technologies previously funded by the State. Investments are typically in the range of $50k-$250k.

Maine also has some specific programmes aimed at renewable resources, forest products and marine/biomedical technologies.

## 2.8 Comparisons Between UK and US Levels of Government Support for Technology Businesses

The scale of the US SBIR programme and related federal government R&D expenditures, coupled with the evidence from the individual case studies described in Sections 3 to 6 of this report, suggest that there are significant differences between the levels of government support available to early stage science and technology based companies in the United States and United Kingdom. This conclusion is reinforced by the results of a comparative survey across 3,600 UK and US firms, carried out by the Centre for Business Research at Cambridge University.[26]

24 In 1999, in response to congressional concerns about the geographical concentration of SBIR awards in a small number of states, Congress established the Federal and State Technology Partnership (FAST) programme to help companies in other states compete more effectively for funding. The FAST programme operated by the SBA provided modest levels of matching federal funding on a competitive basis to states wishing to establish consulting and training programmes to help small firms win SBIR awards. The federal budget for FAST, worth $2m nationally in 2003, was discontinued in 2005, though many states continue to fund advisors at a modest level to provide this sort of help.

25 The DTI's Grants for R&D programme offers four different categories of grants, ranging from 'Micro' (Up to £20,000 with the company funding 50% of the project costs) to 'Exceptional' (up to £500k grant with the company funding 65% of project costs). The majority of government funding under this scheme goes into Development Projects which provide 35% of project costs (higher in Assisted Areas) with a cash ceiling of £200k per grant. Scotland and Northern Ireland have broadly similar approaches, but tend to be a little more generous.

26 *UK Plc: Just How Innovative are We?* Findings from the Cambridge-MIT Institute International Innovation Benchmarking Project; Andy Cosh, Alan Hughes, Richard Lester et al, Cambridge MIT Institute 2006. Small US firms benefiting from government support in the sample received around five times as much as UK firms, though the US figure probably understates the impact of government R&D "contracts" which were not necessarily all included in the comparison.

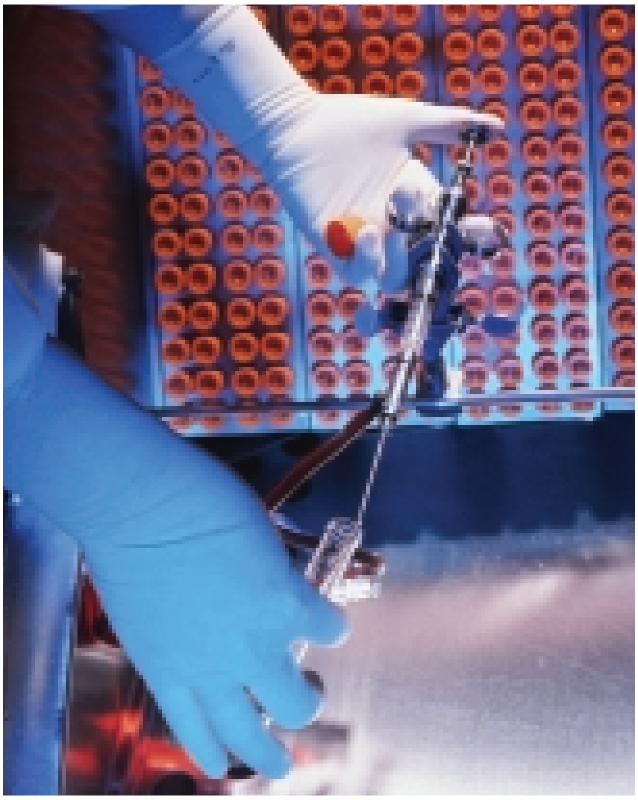


Image courtesy of UK Science Park Association

Further important evidence comes from a report on small technology company funding in the State of Maine by Charles Colgan and Bruce Andrews in 2004. This provides a valuable insight into the impact of the small company support programmes offered by one US state and their relationship with other funding sources for small US science and technology businesses.[27]

In the three years covered by the report, the Maine Technology Institute (MTI) awarded 252 seed grants with a total value of $2.4m and 54 development awards totalling $5.7m. It is interesting to compare the combined average of $2.7m worth of grants per year with the combined figure for the broadly similar DTI R&D grants made to companies based in England. Using the most recent DTI figures for 2004/5 this indicates that, in sterling terms, the State of Maine paid out 70% more per head of population than the DTI – around £1.2m in grants per million people, compared with around £0.7m per million in England.[28]

The recipients of MTI grants were generally very small companies; 73% employed fewer than 10 people. Importantly, the study showed that MTI grant funding represented only 8% of the total funding these companies had received from the public sector; MTI assisted companies had raised a further $100m in federal R&D funding over the three years - $60m from SBIR and STTR awards, and a further $40m from other federal R&D programmes. They had also raised $53m in equity funding (mainly concentrated in the biotech sector) and $42m in debt.

Whilst it is dangerous to generalise from data for a single and rather small US state, it is clear that many other states have broadly similar policies and initiatives. **If Maine is typical, the analysis suggests that US government R&D contracts and grants provide early stage US technology companies with levels of funding which are greater, by an order of magnitude, than the funding available to similar companies in the UK.**

*In sterling terms, the State of Maine paid out 70% more per head of population in R&D grants to companies than the DTI – around £1.2m in grants per million people, compared with around £0.7m per million in England. But Maine's grant funding represented only 8% of the total funding these companies had received from the public sector; MTI assisted companies had raised a further $100m in federal R&D funding - $60m from SBIR and STTR awards, and a further $40m from other federal R&D programmes.*

27 *Evaluation of Maine Technology Institute Programs;* Dr Charles S Colgan and Dr Bruce M Andrews, Centre for Business and Economic Research, University of Southern Maine, December 2004.

28 These estimates are based on the combined figures for DTI Grants for R&D (including Micro, Research, Development and Exceptional Development Projects Grants) given in a written answer on 8th December 2005 by Alan Michael, Secretary of State for Trade and Industry, to a Parliamentary Question by Kitty Ussher MP.

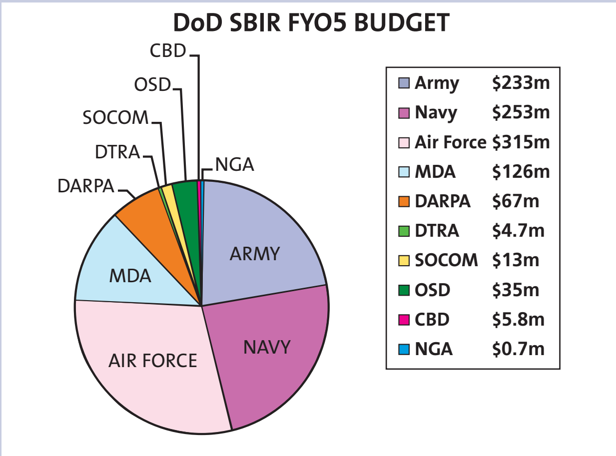
Image courtesy of QinetiQ

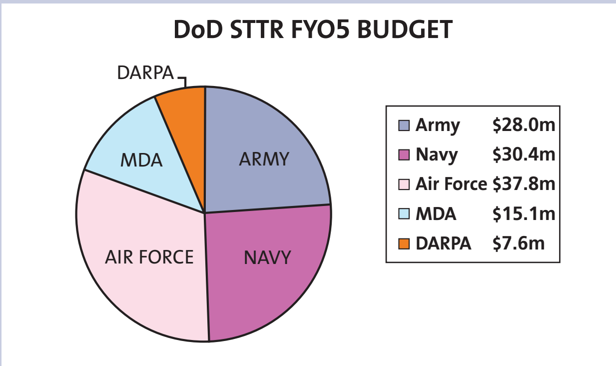
# 3 THE SBIR PROGRAMME AT THE DEPARTMENT OF DEFENSE

## 3.1 Overview of DoD Approach

**The Department of Defense (DoD) is responsible for 52% of the entire SBIR budgets of all federal government agencies, and in 2005 had combined SBIR and STTR expenditures of $1.3 billion. The split between the different departments within the DoD is shown below.**

**EXHIBIT 3.1: DEPARTMENT OF DEFENSE SBIR AND STTR BUDGETS**




**Key Guide:**

**MDA** – Missile Defence Agency
**DARPA** – Defense Advanced Research Projects Agency
**DTRA** – Defence Threat Reduction Agency
**SOCOM** – Special Operations Command
**OSD** – Office of the Secretary of Defense
**CBD** – Chemical and Biological Defense Program
**NGA** – National Geospatial Intelligence Agency

The DoD describes its SBIR/STTR mission as "advancing technology development by small businesses for the military war fighter and the nation". It regards the programmes as just an entry point for small businesses into the overall defense market. They are where small businesses can first demonstrate their capability to meet federal R&D needs. The total DoD R&D budget is some $70 billion and the procurement budget is, of course, much larger. The key role of small businesses in this context is to develop new component technologies that can eventually be incorporated into defence related systems supplied by prime contractors.

Whilst some companies specialising in defence R&D with many hundreds of employees make frequent use of SBIR awards to explore new areas of work, the programme is dominated by very small companies. Half of Phase I award winners employ less than 10 people and two thirds have less than 25 employees. There are special initiatives to bring SBIR contract winners to the notice of larger corporations further along the supply chain.

### Solicitations

Whilst DoD performs an overall coordination function, the DoD's SBIR programmes are largely defined and managed by the individual service units – Army, Navy etc. – and there are important differences of approach between them. As overall co-ordinator, the DoD issues three SBIR solicitations a year: in May, August and November, and one STTR solicitation in February. However, not all branches of the DoD participate in all of these. In 2004 the DoD received nearly 16,000 SBIR proposals. It made 2,075 Phase I awards and 1,173 Phase II awards.

There are three main criteria for evaluating proposals:

- Soundness, technical merit and the level of innovation of the proposed approach, and its incremental progress towards the topic or subtopic solution;
- Qualifications of the firm and team to perform the R&D and commercialise results;
- Potential for commercialisation.

The Department of Defense operates a "Fast Track" policy for SBIR and STTR projects that attract some matching cash for Phase II from outside investors, customers or sponsors. Such projects have a higher probability of proceeding to Phase II and the gap between the two phases is reduced. Fast tracked projects can also receive some interim funding. The proportion receiving this treatment is relatively modest – only about 2% of Army Phase II awards are fast tracked, for example.[29]

29 See also *'An Assessment of the Department of Defense Fast Track Initiative'*; Charles W Wessner et al, National Academy Press 2000.

## Multiple Award Winners and Commercialisation

Like the other agencies, multiple award winners are common. 39% of Phase I award winners have won between two and five Phase II awards previously and 27% have won more than six; so Defense SBIR contracts are clearly an important source of funding for companies with defence related technologies, including those with dual usage.

There has been some concern about firms that have won repeated SBIR contracts, but have faired poorly in terms of commercialising the results and moving to Phase III. As we have seen, commercialisation and/or dual use is of great importance to DoD. The decision process for allocating awards to companies has therefore been biased away from these companies through the introduction of a Commercialisation Achievement Index (CAI). This is calculated from the Commercialisation Report each company is required to submit with any DoD Phase II SBIR proposal. The company's commercialisation achievements for each previous Phase II project must be included in this report and the CAI is automatically computed from this if there are four or more completed Phase II projects. Firms with a CAI in the bottom 10% of the distribution may receive no more than half of the evaluation points available for "commercial potential" in the overall evaluation criteria.

A new measure to assist commercialisation was included in the 2006 Defense Authorisation Act. This requires DoD Departments to identify SBIR projects having the potential for rapid transitioning to Phase III and authorises them to create a "Commercialisation Pilot Program" using SBIR funds to assist this process. It is not yet clear how this will work, but it is possible that the Navy's "TAP" programme (see Section 3.3) will provide the model for implementing this directive.

## Website

All Department of Defense solicitations are issued through a central website **www.dod.sbir.net**.

## 3.2 The Army

The Army's SBIR and STTR programmes are run out of the Army's Research Office in Washington, but the real customers are the Army R&D Laboratories like the Army Research Laboratory and the Simulation Training Technology Center. It is individual scientists and engineers in these laboratories who write the solicitation topics and companies seeking to participate in the Army SBIR programme are encouraged to contact these individuals to get feedback on what technologies they need.

The range of topics covered by the Army is enormous.

The Army runs just one solicitation a year and aims to award contracts within about six months.

The timetable is as follows:

- Solicitation released on the Internet: 1 May;
- Proposals accepted from: 15 June;
- Deadline for proposals: 15 July;
- Contracts awarded: 15 November.

Key statistics are as shown below:

**EXHIBIT 3.2: SBIR/STTR STATISTICS FOR THE ARMY**

| | SBIR | STTR |
|---|---|---|
| *Budget for 2005* | $233m | $28m |
| *Number of Phase I Awards (2004)* | 356 | 62 |
| *Phase I Success Rate* | 10% | 12% |
| *Number of Phase II Awards (2005)* | 259 | 34 |
| *Phase II Success Rate* | 50% | 50% |

There is a two tier evaluation process, beginning with the individual technical programme specifiers and "local" technical management and then moving to a broader Selection Board consisting of ten "Technology Area Chiefs". The process aims to make awards to the best proposals overall, whilst trying to cover all topics included in the solicitation.

Debriefing material, including reviewer comments, is provided to unsuccessful companies on written request within 30 days of notification.

Like other agencies, the Army has modified the basic SBIR template to give some continuity of funding through the "gap" between Phase I and Phase II, and to encourage Phase III funding and commercialisation.

## Gap Funding

The standard Army Phase I contract is $70k, and is designed to fund a 6 month feasibility study. However, a further $50k is available as "Gap Funding" and companies are asked to submit Phase II proposals 4 months after the start of a Phase I project to facilitate rapid progression to Phase II. If a project is selected for Phase II, the $50k gap funding can be released without negotiation.

## Phase II Enhancements and Phase III

The "standard" Army Phase II contract is for $730k, and is designed to fund development of a prototype over a two year period. However, this can be extended by a further $500k for an additional year's work, providing this is matched by a third party funder. This could simply be mainstream funding under one of the Army's non SBIR R&D programmes or it could be with money from a larger defence contractor or a venture capital firm.

So altogether a company can receive $1.35m in Army SBIR funding for each promising project.

Every year, a group of Phase II projects are selected to receive Quality Awards by a panel consisting of government representatives together with industry scientists and business people.

As with other agencies, Phase III funding cannot come from within the SBIR budget, but the Army has other significant R&D procurement programmes operated, through "Broad Area Announcements" and other mechanisms for which businesses can apply. The requirements for new technology defined in these typically have the same basic origins as SBIR solicitations, so any company that has successfully completed an SBIR project is likely to be well positioned to compete for a larger follow-on project if there is a Broad Area Announcement covering the field.

### Army STTR Programme

The Army's STTR programme is much closer to the "standard" model than its SBIR programme, with a $100k Phase I and $750k Phase II. Again there is just one solicitation a year, starting in February with contracts awarded six months later. Nevertheless, there is a good deal of flexibility as regards the balance of collaboration between the small business and the university or research institution involved. The company which proposes a project is allowed to receive anything from 40% to 70% of the overall funding, with the rest going to its academic collaborator.

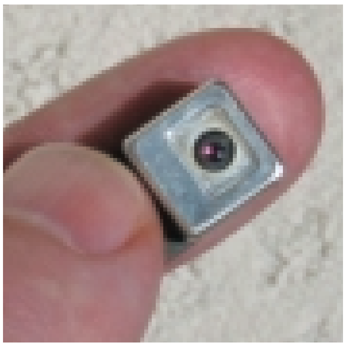
## *Success Stories*

### • Photobit Technology Corporation

Photobit was founded by Dr Eric Fossum and associates from NASA's Jet Propulsion Laboratory in 1995 to commercialise the CMOS image sensor technology he had invented there as manager of its image sensor and focal plane R&D programmes. He has over 90 US patents.

Photobit used an SBIR contract from the US Army Development Test Command to develop high-resolution, high-speed, low-power image sensors for recording the details of missile launches on test ranges. This initial work led to the development of megapixel Complementary Metal Oxide Semiconductor (CMOS) image sensors with speeds greater than 500 frames per second and electronic shuttering capability that could freeze even the fastest motion to create high quality images. Photobit also used an SBIR award from DARPA to develop a micro-sized, micro-power CMOS sensor: its small size and very low power enabled the development of the swallowable pill-camera that is now gaining widespread acceptance for non-invasive medical imaging of the gastrointestinal system.

Image courtesy of Photobit Technology Corporation



The company also won SBIR contracts from NASA and the Ballistic Missile Defence Organisation (now MDA), and the Navy also used Photobit's technology to build airborne weapon separation monitoring cameras.

Though Photobit's early development was largely funded from government contracts, its technology became increasingly used in a range of commercial applications. These included industrial machine vision, high-speed industrial/scientific imaging, biomechanics, and animation systems for motion pictures, television and video games. Cameras using its technology captured various industry awards and were used in films such as 'The Mummy II' and 'Star Wars Episode II'. As the technology improved and manufacturing costs fell, there were also increasing opportunities for volume applications in digital cameras and mobile phones.

By 2000 Photobit had annual revenues of $20m, and on the back of the further significant growth potential from consumer applications the company was able to attract a $26m venture capital investment from Intel, Hitachi and Basler A.G. In 2001, Micron Technology Inc, a $4 billion revenue semiconductor company based in Boise, Idaho, acquired the business in an effort to enter this fast growing market. It did not announce the acquisition for 6 months, an indication of the strategic significance of the move to the corporation. By this time it had integrated Photobit's operations and put in place aggressive plans to grow the business, which it renamed Micron Imaging. As Shawn Maloney, Senior Director of Marketing at Micron Imaging put it, *"Micron does not enter markets it doesn't plan to dominate"*. Micron is now the world's leading supplier of CMOS image sensors.

Dr Fossum has now moved on to another young, growing high-technology company, Siimpel, which is using MEMS technology to develop a high-quality cost-effective optical solution for camera phones. This work has also been supported by various SBIR and other federal government R&D programmes. Dr Fossum says, *"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."*

## • Custom Manufacturing & Engineering, Inc. (CME)

Image courtesy of Custom Manufacturing & Engineering

CME is a "woman-owned small business" (WOSB) serving government and industrial sensors and power markets. Started in March 1997 with three employees by Dr. Nancy P. Crews, its President, CME now has 108 employees and operates out of a 36,000 square foot development and manufacturing facility in St. Petersburg, Florida.

CME's product focus includes:

- Power management;
- Sensor systems;
- Obsolescence: re-engineering older systems and components;
- Electronic components, assemblies, and special cables;
- Power electronics and hybrid power devices;
- Training and simulation instrumentation.

CME won its first SBIR contract in 1998 and continues to be an active SBIR contractor. To date, CME has won 13 SBIR/STTR awards. During 2005, it was working on seven major SBIR projects with Phase II or Phase III status. It also won an $18m contract to provide power supplies to the federal government.

Its most successful Phase III is concerned with the development of an "intelligent power management system" (IPMS) for load management in Army command and control facilities. The Army Phase I contract for this project kicked off in 1998 shortly after CME started. Phase III contracts for IPMS now total $9.4m.

In September 2002, CME was recognised as one of the fastest growing, successful small technology companies in Florida. CME's SBIRs include: a passive microwave radiometer for the Air Force, an antenna control computer (ACC) for a phased array antenna for the Air Force, a generic remote monitoring subsystem (GRMS) for approach lighting systems for the Federal Aviation Administration, an atmospheric propagation sensor/analyzer (APPSA) for the Air Force, a portable SIGINT sensor for the Army, a hotspot fire detector/sensor for the US Forestry Service, a portable high-pressure nitrogen charging system (NCS) for the Marine Corps, threat warning software (TWS) for the United States Special Operations Command, a riverine detection system for USSOUTHCOM, an advanced electrical power system for future ships for the Navy, an energy scavenging system for autonomous surface vehicles for the Navy, and a Micro Fuel Cell (MFC) for Micro Air Vehicle (MAV) Power for the Air Force.

Most of CME's revenues currently come from the defence sector; however, it also sees potential commercial applications for its technology, including intelligent building management systems, smart thermostats, intelligent home and commercial security systems, and power management controllers for industrial facilities, yachts, motor homes, and other heavily equipped mobile electronics platforms.

CME is a recipient of a SBA National Tibbetts Award for being a SBIR "Model of Excellence"[30].

## Website

For more information on the Army SBIR programme see: **www.aro.army.mil/arowash/rt**

## 3.3 The Navy

The Navy's SBIR and STTR programmes are coordinated out of the Office of Naval Research in Arlington, Virginia. The Navy's operations, and hence technology interests, are very wide ranging, and include ships, naval aircraft, land operations (through the Marines) and all the electronic and communications systems associated with them. It also has research interests in training, medicine and weather. The Navy's SBIR programme is therefore relevant to US companies involved in many different areas of technology.

The Navy's SBIR programme goals are "to use small businesses to develop innovative R&D that addresses Navy needs and to implement that technology into a Navy Weapon System".

Of all the services, it has put perhaps the greatest effort into "transitioning" projects beyond Phase II, whether that be for a Navy mission, another DoD mission or the private sector market. Its "Transition Assistance Program" (TAP) is described later.

Key statistics are shown below:

**EXHIBIT 3.3: SBIR/STTR STATISTICS FOR THE NAVY**

| | SBIR | STTR |
|---|---|---|
| *Budget for 2005* | $280m | $35m |
| *Number of Topics in Solicitation* | 136 | 33 |
| *Number of Phase I Proposals* | 2020 | 432 |
| *Number of Phase I Awards (provisional data)* | 300 | 96 |
| *Phase I Success Rate* | 15% | 22% |
| *Number of Phase II Awards* | 250 | 34 |
| *Phase II Success Rate* | 83% | 35% |

30 The Tibbetts Award is named after Roland Tibbetts, godfather to the SBIR program. Tibbetts designed the first SBIR program when he was at the National Science Foundation and was closely involved in its subsequent evolution. He had previously been a Vice President of two successful small technology companies and a founder of an early and successful venture capital firm operating under the US Government Small Business Investment Company (SBIC) Program.

Phase I Navy SBIR awards are similar to the Army - $70k plus a $30k option. Phase II awards are $600k plus $150k. Bids above these levels are considered non compliant. Like the Army, it has a Phase II Enhancement Plan under which it will match subsequent third party funding with Phase III (non SBIR funding) on a 1:3 basis up to $250k. Over 80% of Navy SBIR topics address a specific military application need and they are closely aligned with the Navy's acquisition (i.e. procurement) programmes. Most topics are therefore specified in some detail and awards take the form of contracts.

Management is decentralised, with six programme managers each responsible for the SBIR budget within a different Navy system command (e.g. Office of Naval Research, Naval Air Systems Team etc.).

Some examples of topics from the December 2005 Navy solicitation are listed in Exhibit 3.4 below.

### EXHIBIT 3.4: EXAMPLES OF TOPICS FROM NAVY SBIR 06.1 TOPIC INDEX

- ***Wideband Transmitter for Electronic Attack Aircraft***
- ***Prognostic for Process-Related Integrated Circuits (IC)***
- ***Speech Recognition Technology for Air Traffic Control***
- ***Enabling Internet Protocol Communications***
- ***Automated Reasoner Technology for Managing Military Aircraft***
- ***Improved Electro-Optic Materials for High-Frequency Sensors and High-Speed Optical Switches***
- ***Lift Fan Gearbox Corrosion Monitoring System***
- ***Multi-Purpose Antenna***
- ***Innovative Aircraft Landing Aid Transmission Technology***
- ***Smart Coatings through the Application of Emergent Nano-Technologies***
- ***Affordable, Advanced Lighting Systems***
- ***Individually Adapted Web-based Training***
- ***Field Medical Steriliser to be used in Austere Environments***
- ***Biometric Identity Verification for Sailors in Battle Dress***
- ***Wi-Fi from the Sea***

A one to two page brief is provided on each topic (See Exhibit 3.5 for an example). Each brief describes the work required in Phase I, Phase II and Phase III, and includes comments on potential civilian uses of the technology.

At 83%, the proportion of Phase I projects proceeding to Phase II is much higher than most other agencies. An increasing proportion of Phase II projects also go to Phase III (see Exhibit 3.6). As for all agencies, Phase III contracts are funded through the Navy's normal (non SBIR budget) R&D procurement programmes.

### EXHIBIT 3.5: EXAMPLE OF NAVY SOLICITATION: AUTOMATED REASONER TECHNOLOGY FOR MANAGING MILITARY AIRCRAFT

**TECHNOLOGY AREAS:** Air Platform, Electronics

**ACQUISITION PROGRAMME:** F-35/Joint Strike Fighter

**OBJECTIVE:** Develop and demonstrate an automated reasoner technology to facilitate the efficient management of a fleet of military aircraft and the associated large volume of operational and maintenance data.

**DESCRIPTION**: Massive amounts of data must be analysed and assimilated to accurately and effectively disposition a large fleet of military aircraft. Data of interest include operational data downloaded from the aircraft as well as maintenance and usage data related to the various aircraft subsystems. A great deal of valuable information is contained within these data sets. However, there does not exist a way to assimilate and analyse these data in a timely and meaningful manner. As a result, most of the data is not used. Innovative automated reasoner technology, capable of utilising the vast amounts of data, is needed to determine the current capability and predict the future readiness of the asset, resulting in reduced operating costs and increased operating efficiencies.

Interactive data visualisation technology has taken a step in the right direction by facilitating the decision making process. However, due to the interactive nature of that technology, assimilation and interpretation of the high level data is still required. The goal of this topic is to develop and demonstrate automated reasoners that are more efficient and accurate, enabling the decision maker to leverage in an automated fashion the vast amounts of data that are currently under-utilised. Proposed solutions should extend beyond interactive data visualisation and develop a reasoner that is capable of providing decision makers with the appropriate required actions, and not call for high-level interaction with data that still must be interpreted. Underlying and supporting technology of the automated reasoners should allow the analyst to easily drill down into the data via interactive data visualisation for further offline study and to refine automated techniques. All developed data interfaces should conform to an open systems architecture approach. Such technology would provide the DoD with a greatly improved, reliable and repeatable process for the disposition of these aircraft.

**PHASE I:** Demonstrate the feasibility of designing automated reasoner technology for military aircraft application. Select the aircraft platform(s) and develop a case example for an aircraft propulsion subsystem.

**PHASE II:** Develop a prototype of the automated reasoner technology that will utilise operational as well as maintenance and usage data sets.

**PHASE III:** Finalise the automated reasoner technology implementation with DoD end users and airframe and engine manufacturers and conduct necessary qualification testing.

**PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS:** The methodology and technology have direct applicability to management of civil aircraft and commercial vehicles, and the techniques can be leveraged across industry as well as DoD.

**REFERENCES:**

1. The Joint Strike Fighter (JSF) Prognostics and Health Management.
   **http://www.dtic.mil/ndia/2001systems/hess.pdf**
2. Data Visualisation for Business Intelligence.
   **http://www.fyicorp.com/content/papers/Fleet_Management_Case_Study.pdf**
3. Vandagriff, David (2004). *"The Evolution of Data Visualisation: From Dreary Digits to Dynamic Dashboards."*
   **http://www.dmreview.com/editorial/newsletter_article.cfm?nl=bireport&articleId=1010516&issue=20075**

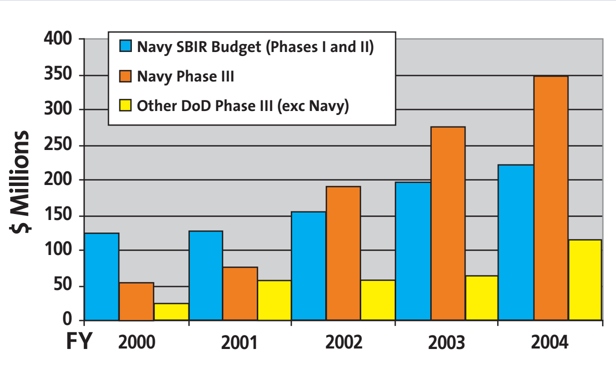
**KEYWORDS:**
Interactive; Visualisation; Maintenance; Usage; Aircraft; Disposition

## Navy Transition Assistance Programme (TAP) and Phase III Funding

As indicated earlier, the TAP is a unique feature of the Navy's SBIR programme. Its aim is to facilitate Department of Defense use of Navy-funded SBIR technology and assist SBIR-funded firms to speed up the rate of transition to Phase III funding. The Transition Assistance Programme comprises a series of workshops, training and briefing meetings over a 10 month period which all Phase II award winners are required to attend. The goal is to help companies develop their commercialisation plans and present their technology to both the DoD and the prime contractors who represent the key route to mainstream procurement. The process culminates in an annual "Navy Opportunities Forum" during which companies that have successfully completed the TAP programme can present their business opportunities to a targeted audience of DoD personnel, prime contractors and other interested parties. Typically there are around 100 SBIR companies presenting and 400-500 representatives from DoD and the private sector. There is a parallel process to inform prime contractors of the potential benefits of the SBIR programme.

The success of the TAP initiative is evidenced in the increasing levels of phase III (mainstream) funding going to Navy SBIR award winners. (See Exhibit 3.6 below).

**EXHIBIT 3.6: PHASE III FUNDING OF NAVY SBIR PROJECTS**




Source: US Navy
Notes: (i) Phase III data from Individual Contracting Action Reports Forms (DD 350).
(ii) Total FYO4 DOD Phase III funding was $456m. The Navy represented $346m. (76%) of this and comprised 114 separate contracts with 81 individual firms.

In 2003, the Navy awarded 67 Phase III contracts to 55 companies worth a total of $299m. The largest beneficiary, Digital Systems Resources Inc, received contracts worth $40m; the smallest was a contract worth just $29,000. The average value of Phase III awards amongst these companies was $5m.

One prime contractor, Lockheed Martin, has spent 10%-15% of its independent (i.e. sub-contracted) R&D budget with SBIR companies, most of which it has met at the Navy Opportunity Forum.[31]

## Success Stories

The Navy regularly publishes profiles of SBIR success stories, and some examples are listed below:

### • Multispectral Solutions Inc (MSSI)

Founded in 1988 by Dr Robert Fontana, MSSI is now a recognised leader in Ultra Wideband (UWB) technology for communications, precision location and radar applications. MSSI has won a number of SBIR contracts over its history and in 2004 was awarded a $24.5m contract for the production of UWB based Aircraft Intercommunications Systems.

### • *n*Gimat Company

*n*Gimat was founded in 1993. It is an intellectual property company and manufacturer of engineered nanomaterials for nanopowders, thin films and devices. Its core technology is combustion chemical vapour deposition (CCVD) and was invented by the company's founder, Andrew Hunt. Originally called Microcoating Technologies, the company was founded immediately after Dr Hunt received his Doctorate from Georgia Institute of Technology.

The firm is a classic "soft start" and was financed largely from individual public and private sector customer contracts until it brought in $4m of venture capital in 1999. By this time it employed 60 people. *n*Gimat has built up a portfolio of 36 issued US patents.

The company has been awarded SBIR contracts from a variety of agencies, including the Department of Defense (Navy, Army, Air Force, DARPA and Missile Defense Agency), National Science Foundation, the Department of Energy, The National Institutes of Health, the Environmental Protection Agency and the National Aeronautics and Space Administration. In 2005 these included a Phase I award from the Environmental Protection Agency to develop a portable bacteria detection instrument, and a $1.46m Phase II award from the National Institutes of Health to develop gene expression analysis technology.

An important $700k STTR award from the Navy was concerned with thin film coatings and passive devices that can be embedded on printed circuit boards, freeing up space for miniaturisation. This led on to a $7m development and licensing agreement with Rohm & Haas. Today it has development programmes with a number of technology and industrial companies from around the world.

The SBIR programme has played a key role in *n*Gimat's business. *"I would not have had a company without it"* comments founder Andrew Hunt.

31 Transitions Volume 1, Issue 2 2004, US Navy TAP Newsletter.

## Website

The Navy's SBIR website is at **www.navysbir.com**.

## 3.4 Defence Advanced Research Projects Agency (DARPA)

DARPA's mission is to be an "enabler for radical innovation for national security". It operates in three principal areas:

- Finding technical solutions for national problems; *the current focus is on biological warfare, defense information assurance and measurability;*
- "Operational dominance"; *current focus is on precision munitions, dynamic command and control for mobile networks and near real time logistics planning;*
- Development and exploitation of high risk technologies for national defense.

DARPA's annual budget is around $3 billion, 98% of it spent with external organisations. To assist the transitioning of new technology into the individual operational departments of the DoD, DARPA executes about 70% of its projects through the individual service that might eventually procure a given technology.

Since its establishment in 1958, DARPA has had a key role in the development of numerous important new military technologies, including space and missile defence programmes, stealth technologies, the Global Positioning System (GPS) and MEMs devices. Its best known technology success is the Internet, where it pioneered key protocols and architectures.

DARPA's fundamental focus is high risk, high pay off technologies and the avoidance of strategic "surprises" based on new technologies.

DARPA has 160 programme managers and it has much greater flexibility than other Department of Defense agencies with regard to contractual terms and speed of response. The 97.2% of its extramural budget which is not dedicated to SBIR or STTR contracts is also accessible to small businesses through participation in "Broad Agency Announcements" and other mechanisms; the SBIR programme should be seen as just a first step on the ladder. A very significant proportion of DARPA's overall $3 billion budget is believed to be spent with small businesses.

The overall DARPA SBIR/STTR Programme Manager is Connie Jacobs, a federal government industrial liaison specialist, who has been involved with the SBIR programme since 1982.

The key statistics for DARPA's SBIR programme are as shown below:

**EXHBIT 3.7: SBIR/STTR STATISTICS FOR DARPA**

| | SBIR | STTR |
|---|---|---|
| *Budget for 2006* | $68m | $8.5m |
| *Number of Topics in Solicitation (approx.)* | 30 | 10 |
| *Number of Phase I Awards (approx.)* | 70 | 20 |
| *Number of Phase II Awards (approx.)* | 45 | 10 |
| *Phase II Success Rate* | 64% | 50% |

SBIR solicitation topics are published once a year in November. The STTR topics are published in February.

DARPA's SBIR projects normally involve a $99k Phase I award lasting 6 months and a $750k Phase II award lasting 20-24 months. However, DARPA funding exceeds the Phase I and Phase II norms fairly frequently and it is not uncommon for SBIR projects to be supplemented with mainstream funding. The maximum amount that has been added to a single SBIR project in this way is $4.5m.

Examples of topics from the 2005 solicitation are listed in Exhibit 3.8, whilst details of one of these topics are given in Exhibit 3.9.

**EXHIBIT 3.8: EXAMPLES OF TOPICS FROM DARPA SBIR 05.2 TOPIC INDEX**

- *Smoke and Flame Resistant Large Core Plastic Optical Fibre for Highly Efficient Light Distribution in Navy Vessels*
- *Situational Awareness of Computing Assets Outside of Direct Control*
- *Smart Scalpel*
- *Advanced Technologies for Display of 3D Urban Models*
- *Chip-Scale Technologies for Giga-band Signals*
- *Integration Technology for Trustable Integrated Circuits*
- *Bioluminescent Detection of Chemical Agent Contamination*
- *Wavelength Conversion of Pulsed Fibre Lasers*

#### EXHIBIT 3.9: EXAMPLE OF DARPA SBIR TOPIC BRIEF - NON INTRUSIVE HEALTH MONITORING FOR POST-BATTLE WELLNESS MANAGEMENT

**TECHNOLOGY AREAS:** Information Systems, Biomedical

**OBJECTIVE:** Create supportive and non-intrusive health-monitoring technologies that will facilitate the transition of injured combat veterans into extended care and independent living environments.

**DESCRIPTION**: Long-term support and care of military personnel is of paramount importance to the Department of Defense. The need for high-quality monitoring of the medical condition of soldiers recovering from battle-related injuries can significantly delay, and in some cases prevent, their return to independent living. DARPA is interested in the development of innovative, low-cost, non-invasive "trip-wire" systems capable of monitoring injured and recovering veterans and detecting problems with their recovery. The envisioned health-monitoring system is expected to provide both a safety net that can detect when the soldier needs assistance and a detection/prediction capability that enables the system to advise health care providers of changes in important medical indicators, e.g., decrease in mobility. In terms of technical approach, this implies that simple sensor-only solutions will not be effective. Instead, solutions must integrate Artificial Intelligence (AI) or cognitive systems technologies with sensors (or sensor data), to provide a reasoning capability that enables the system to detect and diagnose trends rather than monitor for single data points.

To illustrate, a 30% decrease in mobility over a one week period is a trend whereas a body temperature reading of 98F is a single data point. These capabilities are important to all recovering soldiers and are even more important to those who live alone. This research must address the challenges presented by a recovering soldier who is likely to be suffering from multiple injuries and is at the same time generally active. The recovering soldier is also likely to exhibit changing medical and behavioural profiles as he/she heals and becomes more adept at using wheel chairs, prosthetic limbs or other assistive devices. Conversely, in the early stages of using such devices or in the early stages of recovery, the likelihood of new injury or mishap is also greater. DARPA is seeking solutions that will benefit soldiers with a wide variety of impairments who are ready to make a transition back to independent life. Integrated approaches are preferred and should include technologies for in-home sensing, monitoring and diagnosing medical conditions, and communicating summary results and alerts to appropriate medical personnel. Proposed approaches must address reasoning with uncertainty, discriminating between changes that are within normal variation and those indicating a problem, and minimise false alarms. Offerors must describe how the proposed research effort will protect individual's privacy rights, is cost effective, and does not place additional burden on healthcare professionals and volunteer caregivers (e.g., the person's family). Possibly relevant technologies include Bayesian or other forms of probabilistic/uncertain reasoning, learning of probabilistic/uncertain models (both structural learning and parameter estimation), sensors and sensor fusion, human cognitive and behavioral modelling.

**PHASE I:** Perform initial assessment and specify the design of a system addressing these requirements. Include a plan to demonstrate the relevance for the proposed system.

**PHASE II:** Expand the concept developed under Phase I. Develop a complete demonstration system and demonstrate performance in a variety of hypothetical scenarios.

**PHASE III DUAL USE APPLICATIONS:** The technology developed in this topic is applicable to monitoring injured soldiers and other at-risk individuals, including those that experience traumatic events or have chronic medical conditions, e.g., fragile diabetics.

**REFERENCES:**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2. National Mental Health Association, *"Mental Health Fact Sheets"*. **http://www.nmha.org/infoctr/factsheets/index.cfm.**
3. Martha W. Pollack, *"Assistive Technology for Aging Populations,"* presented to the United States Senate Special Committee on Aging, April 24, 2004. **http://www.eecs.umich.edu/%7Epollackm/Pollack-web_files/senate-testimony.pdf.**
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**KEYWORDS:** Non-Invasive Medical Monitoring, Uncertainty, Cognitive Systems, Artificial Intelligence.

## Success Stories

### • HNC Software Inc

The Hecht-Nielsen Neurocomputer Corporation (HNC) was founded by Robert Hecht-Nielsen and Todd Gutschow in 1986. Hecht-Nielsen was a pioneer in the development of neural network technology and since 1985 has been on the faculty of the University of California in San Diego. He is currently Adjunct Professor of Electrical and Computer Engineering at the university. HNC's early business was training and consulting for clients in financial services and other organisations that wanted to introduce neural network applications software.

The company won its first SBIR award two years after its formation in 1988 and it went on to receive 15 Phase I and 14 Phase II awards totalling $6.7m. Besides awards from DARPA, it also received SBIR contracts from BMDO, the Army, Navy and Air Force.

The DoD's primary interest was to speed up target recognition and improve the accuracy of munitions. Its funding has supported research and development in this and a range of closely related fields at HNC.

A new class of predictive software known as "Predictive Software Solutions" (PSS), which HNC developed with the support of these DoD SBIR contracts, has gone on to have a wide range of commercial applications. These included FalconTM, a patented PSS developed to detect credit card frauds at the time of the transaction.

HNC continued to win contracts from DoD under mainstream R&D programmes, after it had grown beyond the SBIR size criteria. In 1998 it commenced a jointly funded $3.3m project with DARPA to build a "cortronic" neural network, a concept conceived by Robert Hecht-Nielsen as the "universal computing process". DARPA was "sufficiently interested to help him flesh out his ideas a little" said Ronal L Larson, assistant director of Intelligent Software and Systems in DARPA's Information Technology Office.[32]

HNC Software IPO'd in 1995 and by 2002 it had annual revenues of $226m and 1500 employees. In 2002 it was acquired by Fair Isaac, a US software company with closely related interests.

### • II – VI Incorporated

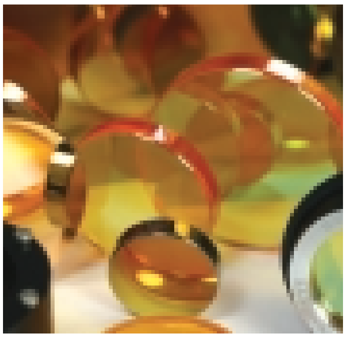
Image courtesy of II – VI Incorporated

II-VI was founded with two employees in 1971 to develop and market optical and electro-optical materials, devices and components for use in lasers and laser systems. Between 1984 and 1996 it was awarded thirteen SBIR contracts from DARPA, the Army, Navy, Air Force, Ballistic Missile Defense Organisation and NSF.

By 1997, the company was generating 25% of its revenues from SBIR-related products, though 75% of these revenues were derived from non-military applications. They included components for carbon dioxide lasers used in the manufacture of motor vehicles, steel office furniture and machine tools, as well as laser marking applications.

By 2005 the company, which is listed on NASDAQ, had revenues of $194 million, profits of $25m and 1500 employees, twelve times the number it had in 1984 when II-VI entered the SBIR programme.

### Website

Further information can be obtained from the DARPA SBIR website at **www.darpa.mil.sbir/**

*HNC Software Inc won its first SBIR award two years after its formation in 1988 and it went on to receive 15 Phase I and 14 Phase II awards totalling $6.7m. Besides awards from DARPA, it also received SBIR contracts from BMDO, the Army, Navy and Air Force.*

32 *Government Computer News*, October 26th 1998.

Image courtesy of TTP Group plc

# 4 THE SBIR PROGRAMME AT THE NATIONAL INSTITUTES OF HEALTH

## 4.1 Overview

**The National Institutes of Health (NIH) are part of the Department of Health and Human Services (HHS). Their mission is to improve human health through biomedical and behavioural research, research training and communications. The NIH's overall budget in financial year 2005/06 is $29 billion (equivalent to $96 per US citizen), of which $24 billion is spent externally.**

The NIH has identified a general need to work much more closely with industry to find cures for disease and it has stated that it will "aggressively seek out partnerships with private companies". In principle, the whole of this external R&D budget is accessible to companies.

The statistics for the NIH's SBIR and STTR programmes are shown below:

**EXHIBIT 4.1: SBIR /STTR STATISTICS FOR NATIONAL INSTITUTES OF HEALTH**

| | SBIR | STTR |
|---|---|---|
| *Total Budget (Financial Year 2005)* | $582m | $69m |
| *Number of Phase I Awards Per Year (2003)* | 981 | 95 |
| *Phase I Success Rate (2003)* | 24% | 27% |
| *Number of Phase II Awards Per Year (2003)* | 327 | 18 |
| *Phase II Success Rate* | 44% | 43% |
| *Indicative Phase I Award Size and Timescale* | $100k (6 months) | $100k (1 year) |
| *Indicate Phase II Award Size and Timescale* | $750k (2 years) | $750k (2 years) |

The NIH also manages SBIR programmes totalling around $10m per annum for some smaller federal government agencies.

The NIH adopts indicative award levels based on the national norm. However, it recognises that drug discovery and diagnostics projects require substantial sums of money and it encourages firms to propose "realistic" and "appropriate" budgets for research. Phase I and Phase II awards larger than the $100k and $750k norms are fairly common at the NIH. For example, KineMed Inc received a $4.5m Phase II award in 2004 to develop cancer cell biomarkers. Vaccinex Inc received a $600k Phase I award in the same year to develop new immunotherapies for prostrate cancer. Other examples are given later in this chapter.

The NIH has 23 separate Institutes. (See Exhibit 4.2). Each has its own SBIR budget, areas of interest and SBIR programme management team. Jo Anne Goodnight has been Programme Coordinator for the overall NIH SBIR and STTR programmes since 1999. A bioscientist by background, she has been involved in research programme management in government for over 20 years. She is a recipient of a Tibbetts award from the Small Business Administration for her "leadership role in making SBIR and STTR programmes more accessible and more effective".

**EXHIBIT 4.2: THE PRINCIPAL NIH FUNDING CENTRES**

- *National Institute on Aging*
- *National Institute on Alcohol Abuse and Alcoholism*
- *National Institute of Allergy and Infectious Diseases*
- *National Institute of Arthritis and Musculoskeletal and Skin Diseases*
- *National Institute of Biomedical Imaging and Bioengineering*
- *National Cancer Institute*
- *National Institute of Child Health and Human Development*
- *National Institute on Drug Abuse*
- *National Institute on Deafness and Other Communication Disorders*
- *National Institute of Dental and Craniofacial Research*
- *National Institute of Diabetes and Digestive and Kidney Diseases*
- *National Institute of Environmental Health Sciences*
- *National Eye Institute*
- *National Institute of General Medical Sciences*
- *National Heart, Lung and Blood Institute*
- *National Human Genome Research Institute*
- *National Institute of Mental Health*
- *National Institute of Neurological Disorders and Stroke*
- *National Institute of Nursing Research*
- *National Center for Research Resources*
- *National Center on Minority Health and Health Related Disparities*

## 4.2 Solicitations

The NIH releases a 100 page "omnibus award solicitation" once a year in January and has three cut off dates each year for receipt of applications against these requirements. These are 1 April, 1 August and 1 December. The solicitation provides detailed guidance for applicants and defines the fields in which projects are sought. It is up to applicants to identify the individual Institutes which have research priorities most closely matching their interests. However, the NIH is essentially looking for "investigator initiated" research, and most of its SBIR awards are therefore described as "grants" rather than "contracts".

Examples of topics from a selection of Institutes are listed in Exhibit 4.3. In each case the Institute provides further detail behind the topic. An example is provided in Exhibit 4.4.

**EXHIBIT 4.3: EXAMPLES OF SBIR TOPICS FOR SELECTED NIH INSTITUTES**

### National Cancer Institute

- **Antibody array for cancer detection;**
- **Methods for innovative pharmaceutical manufacturing and quality assurance;**
- **Nanoparticle biosensors for recognition of exposure and risk analysis in cancer;**
- **Synthesis and high throughput screening of in vivo cancer molecular imaging agent;**
- **Home centre co-ordinated cancer care system.**

### National Institutes of Medical Health

- **Interactive web based networking tool for linking services and interventions research, training and education programs.**

### National Heart, Lung and Blood Institute

- **Develop and test a diagnostic tool for von Willebrand Disease.**

### Centre for Disease Control and Prevention

- **New laboratory tests for tuberculosis and detection of drug abuse; technology to develop an ambient temperature specimen transport system.**

**EXHIBIT 4.4: EXAMPLE OF RESEARCH TOPIC PUBLISHED BY NATIONAL CANCER INSTITUTE (NCI)**

### 196 Antibody Array for Cancer Detection

The purpose of this initiative is to develop an antibody array in collaboration with the NCI's Early Detection Research Network (EDRN). It is anticipated that the collaboration will provide sets of antigens by the EDRN investigators and permit the development, production and dissemination of antibody microarray technologies for the research community engaged in research focused on early detection and risk assessment of cancer. The specific objectives are:

- Prepare and purify biomarker-specific antibodies in the form of recombinant antibodies or monoclonal antibodies (mAb);
- Develop and/or improve methodologies for quantitative measures of the bound antigens on Ab microarrays;
- Perform initial validation studies in collaboration with EDRN using the antibody microarrays.

Currently there is no single marker or combination of biomarkers that has sufficient sensitivity and specificity to diagnose asymptomatic cancer or early stage cancer. However, recent developments in gene and proteomic profiling of precancerous and cancerous lesions suggest that patterns of markers may be used to distinguish cancer and non-cancer with high sensitivity and specificity (95-100%). Antibody microarrays will provide a fast, reliable, high-throughput, sensitive, and quantitative detection tool of multiple differentially expressed antigens (annotated proteins and post-translational modified proteins) from a limited amount of sample (e.g. 20ul of serum) obtained through a minimally invasive method. Involvement of biotech, via SBIR mechanism, with high-throughput technologies will further strengthen the EDRN efforts in early detection and in dissemination of these technologies.

**Phase I Activities and Expected Deliverable:** Establish the proof of principle – develop a microarray for detection of 3 markers, which will be selected by the EDRN, and demonstrate that the tiled antibodies perform as well or better than a conventional ELISA in detection of these markers in serum of cancer patients.

**Phase II Activities:** 1) Development of an antibody array with a capability to simultaneously detect 50 biomarkers; 2) Validate the antibody array in a population based study in collaboration with EDRN investigators. At least 1000 microarrays will be reprinted and tested by EDRN investigators.

Applications for NIH awards are reviewed by external peers from academia and/or industry; the NIH SBIR programme staff do not participate in this review process. The merit of a proposal is determined by scientists and engineers, and applicants automatically receive a debriefing on their comments. The key evaluation criteria are:

(i) Significance (Is there a real problem/commercial potential?);
(ii) The proposed approach (research design, feasibility);
(iii) Level of innovation;
(iv) Experience of "principal investigator" and research team;
(v) Environment (Are the facilities and resources suited to the project?).

Unsuccessful project applications can be revised and submitted twice more.

## 4.3 Commercialisation

As discussed earlier, the NIH has put particular emphasis on developing an approach that deals with the commercial realities of healthcare R&D. There are four special features of the NIH's SBIR approach that address this issue:

- Fast track funding;
- Phase III Competing Continuation Awards;
- Overall size of awards;
- Supplementary consulting programmes.

These are discussed further below. In addition, "no cost time extensions" and "administrative/competitive supplements" are also available.

### Fast Track Funding

The aim of the Fast Track Initiative is to enable businesses to submit both a Phase I and Phase II proposal for concurrent peer review. It has the potential to eliminate the gap that would otherwise exist between completion of Phase I funding and commencement of Phase II. Fast track applications require the submission of a "Commercialisation Plan" alongside the Phase I and Phase II proposals. Letters of support from potential commercialisation partners and/or Phase III funders are desirable. In 2003, there were 61 NIH SBIR Fast Track Awards and 5 STTR Fast Track Awards. The success rate for companies seeking Fast Track status was around 23%.

### Competing Continuation Awards

The NIH recognises that developing promising drug compounds and medical devices takes much more money and time than is available under the "standard" SBIR regime. Competing Continuation Awards are available to Phase II awardees requiring further funding to continue development work and conduct preclinical studies of drugs or devices that ultimately require clinical evaluation, regulatory approval, or for refinements to "durable medical equipment designs". They generally provide funding of $750k to $1m per annum for up to three years.

## Size of Awards

Whilst the NIH uses the $100k Phase I and $750k Phase II guideline for its SBIR programme, in practice individual awards vary widely in size and they can be significantly larger than these guidelines. In addition, companies quite often receive multiple awards. Some examples selected from the 2003 awards illustrate this.

- **Lyncean Technologies, Inc.,** is a Palo Alto based company, founded by a small team, with its origins at Stanford University. In 2002, the NIH awarded it a Phase I SBIR award to develop a table-top synchrotron light source to enable researchers to undertake high-resolution protein crystallography in their own laboratories. In March 2006, the prototype demonstrated feasibility by producing its first X-ray beam. At the conclusion of the Phase II effort in 2006, a total of $9.5M had been awarded for this development. A multi-institutional research centre, funded in 2005 as part of the National Institute of General Medical Sciences Protein Structure Initiative, will use Lyncean's technology at its Scripps Research Institute site.

- **Novasite Pharmaceuticals** is a drug discovery and development company that is identifying new therapeutics for common diseases through the modulation of membrane receptors. In 2003 Novasite was awarded $1.8m in five separate SBIR awards from the NIH. Earlier, in 2000, it had been awarded $3.3m in Phase I and Phase II NIH awards to develop its "Expanded Target Drug Discovery Technology", and in 2002 it was awarded a $2.4m grant to develop anti obesity drug candidates. One of its 2003 Phase I awards led on in 2005 to a $3.4m Phase II award for screening of G-protein coupled receptors, a family of drug targets responsible for 40% of all commercial drug sales.

  Novasite Pharmaceuticals was originally started as a majority owned subsidiary of Applied Molecular Evolution Inc (AME), a NASDAQ listed company sold to Eli Lilly for $400m in 2004. AME had previously been a recipient of SBIR awards in its own right, including a $1m award for the development of a potential treatment for cocaine addiction in 2001.

- **Insightful Corporation** is a NASDAQ listed provider of software solutions for the analysis of numeric text data and is headquartered in Seattle.

  In 2003 it won eleven separate SBIR awards from the NIH totalling $2.7m. In previous years it also received awards from the National Science Foundation, DARPA and the US Army.

## Supplementary Consulting Programmes

To assist awardees with commercialisation, NIH offers consulting support to SBIR awardees. There are two principal programmes:

(i) Niche Assessment Programme for Phase I Awardees.

Foresight Science and Technology, a specialist consulting company based in Providence, Rhode Island, provides this service, currently available to 150 NIH SBIR Phase I awardees. The key output is a report covering:

- The needs and concerns of end-users that drive the competitive opening in the market;
- Competing technologies and products;
- The competitive advantage of the technology;
- Who the key competitors are likely to be;
- The likely price customers will pay;
- What will drive the market;
- The key standards, regulations, and certifications influencing buyer acceptance;
- The market size and what share should be sought;
- The potential customer, licensee, investor, or other commercialisation partner;
- A commercialisation strategy that includes tasking and a schedule for implementation.

(ii) Commercialisation Assistance Programme for Phase II Awardees.

Larta Institute is the NIH contractor in this case and is another specialist technology transfer and consulting firm. It is based in California with offices in Washington and Chicago. Larta's programme involves a mixture of workshops and consultation over a ten-month period, the aim being to help companies:

- Find investors;
- Develop or improve strategic business planning;
- Develop licensing opportunities;
- Establish strategic partnerships;
- Seek regulatory approvals and perform clinical trials.

There are slots for 125 participating companies.

## 4.4 Evaluation of NIH SBIR Programme

In 2002 the National Institutes of Health conducted a detailed evaluation of its SBIR programme through a survey of all 1,052 recipients of Phase II SBIR awards made between 1992 and 2001.[33] Meaningful data was generated from 768 of these companies.

33 *National Survey to Evaluate the NIH SBIR Program, Final Report;* NIH Office of External Research, July 2003. The report's authors are JoAnne Goodnight and Susan Pucie from NIH and Stephanie Karsten et al from Humanitas Inc.

Whilst clearly many of the awards would have been too recent to have generated commercial results, the survey found that:

(i) 666 patents, 453 copyrights and 322 trademarks were generated through these programmes;
(ii) 52% of awardees received **additional** Phase I or Phase II awards relating to the continued development and exploitation of their core technology (e.g. in other applications);
(iii) Of the 399 awardees who won additional SBIR awards, 40% also received non SBIR funding. (In total 281 award winners received additional funding from non SBIR sources);
(iv) 73% of respondents reported commercialising new health-related or improved products, processes and/or services as a result of the programme, including 164 licenses and $821m in cumulative sales;
(v) The NIH's $551m SBIR "investment" in the 768 respondents generated $821m in cumulative sales;
(vi) 48 drugs and medical devices received FDA approval;
(vii) 98% of respondents said that SBIR support had been, or would be, very important in the research and development of the product, process of services developed under the funded projects;
(viii)64% said that projects would not have been pursued without SBIR support key additionalities being:
- impact on pursuit of a high risk idea or action (87%);
- hiring additional personnel (80%);
- raising additional capital (44%);
- credibility or visibility for finding partners (70%).

## 4.5 *Case Studies*

### • Transonic Systems Inc

Transonic Systems was founded in 1983 by Cornelius Drost who, as Senior Research Associate at the College of Veterinary Medicine at Cornell University, invented the transit-time ultrasound flow meter to measure blood flow.

Initially used in animal laboratory work, Transonic's products are now used in a wide range of research and human healthcare applications. These include monitoring during surgical procedures and haemodialysis.

Transonic has been the recipient of many NIH SBIR and STTR awards over the last decade. They include:

| | | |
|---|---|---|
| 1995 to 2001 | Tools and techniques to measure flow and pressure in mice | Phase I |
| 1995 to 1998 | Measurement of haemodialysis access flow and recirculation | Phase I and II |
| 1998 to 2003 | Fibre bundle monitoring during haemodialysis and haemofiltration | Phase I and II |
| 2000 to 2004 | Flow measurement at dialysis access salvage intervention | Phase I and II |
| 2000 to 2001 | Cardiac output monitor for children's ICU and surgery | Phase I |
| 2000 to 2005 | A flow meter with telemetry for chronic animal studies | Phase I and II |
| 2003 to 2004 | New device for monitoring diabetic microcirculation | Phase I |
| 2005 to date | Flow meter for paediatric hydrocephalic shunts | Phase I |

In 2000 Transonic Systems received the Tibbetts Award for the use of the SBIR programme to develop technology for monitoring blood flow while patients are undergoing dialysis treatment. It has also received various industry awards.

Today it has 130 employees and has regional offices in the USA, Netherlands and Taiwan, and worldwide distribution.

### A Lost UK Opportunity?

Dr Helen Lee is an entrepreneurial academic who moved, from a high-powered job at Abbott Laboratories in Chicago, to set up the Diagnostic Development Unit at the Department of Haematology, University of Cambridge. Her objective was to develop innovative, simple, rapid and inexpensive tests for the detection of infectious agents in resource-limited settings and particularly, in developing countries. She built an academic team of 12 and won substantial research funding from the Wellcome Trust, the World Health Organisation and the US National Institutes of Health to develop a rapid Chlamydia test.

Dr Lee chooses to do her academic research in Cambridge because of the quality of its science. However because of the availability of SBIR awards in the US, she set up her company to develop new products based on the technology in Sunnyvale, California. Four key scientists from the Cambridge University team moved to California to continue the new research.

Dr Lee says: *"We would all have preferred to establish the company in Cambridge, rather than California, because Cambridge is where the research and development has taken place. But the funding gap for start-up biotech companies in the UK is such that we did not have a choice."*

Cambridge University and the Wellcome Trust retain shareholdings in the business and the Wellcome Trust's Technology Transfer Division provided the company with a £750,000 investment. The company has since obtained a series of SBIR awards from the US National Institutes of Health, including Competing Continuation Awards, totalling just over $5.5M.

The NIH's SBIR awards have provided almost 100% of the funding for the proof of concept and development programmes for rapid diagnostic tests aimed at HIV, Hepatitis B and Hepatitis C.

These complement the work on Chlamydia testing and will help improve the safety of blood transfusions in developing countries, a priority area identified by the US National Heart, Lung and Blood Institute, which has provided the SBIR funding programme. Diagnostics for the Real World has a non-traditional and challenging business model which uses a two-tier pricing strategy. In developed countries, the aim is to sell tests at premium market prices; in developing countries the prices will be close to manufacturing cost in order to ensure that people in resource-limited settings have access to high quality diagnostic tests.

## 4.6 Website

Further information on the NIH SBIR programme is available at **http://grants1.nih.gov/grants/funding/sbir.htm**

Image courtesy of TTP Group plc

# 5 THE SBIR PROGRAMME AT THE NATIONAL SCIENCE FOUNDATION

## 5.1 Overview

**The primary function of the National Science Foundation (NSF) is to support basic scientific and engineering research and promote science and engineering education, although a small portion of the NSF budget also funds applied research. Its nearest UK equivalents are the UK Research Councils, though the match is imprecise as some activities of the US National Institutes of Health (NIH) are similar to the Medical Research Council (MRC) and the Biotechnology and Biological Sciences Research Council (BBSRC) in the UK.[34]**

The NSF's annual budget is currently around $5.5 billion and it funds about 20% of all federally supported basic research conducted by America's colleges and universities. Its external R&D budget is about $3.8 billion.

The NSF's combined SBIR and STTR budgets are currently worth around $105m a year.

The detailed statistics are shown below:

**EXHIBIT 5.1: SBIR/STTR STATISTICS FOR THE NATIONAL SCIENCE FOUNDATION**

| | SBIR | STTR |
|---|---|---|
| *Total Programme Budget 05/06* | $94m | $11m |
| *Number of Phase I Proposals Per Year (approx)* | 1600 | 200 |
| *Number of Phase I Awards Per Year (approx)* | 240 | 30 |
| *Phase I Success Rate* | 15% | 15% |
| *Number of Phase II Awards Per Year* | 100 | 13 |
| *Number of Phase II B Awards Per Year* | 30 | 3 |
| *Phase II Success Rate* | 50% Approx | 50% Approx |

In keeping with its central role as a funder of basic research, the NSF does not specify detailed project topics. This contrasts with mission orientated agencies like the Department of Defense, which can act as final customer for commercialised products. Instead the NSF's solicitations list "broad market" driven technology topics with an emphasis on national needs.

## 5.2 Award Structure

Phase I NSF awards are up to the "standard" $100,000. However, to help bridge the gap to "Phase III" commercialisation, the NSF has split its Phase II awards into two parts:

(i) Phase II – "Concept Development", with NSF funding up to 100% of project costs and a maximum award of $500,000;

(ii) Phase II B – up to a further $500,000 of NSF funding on a 1 to 2 matching basis with funds from another "investor". This can be a venture capital firm, another federal or state government source, a corporate partner, or a mixture of these. The matching funds can be used to fund non-research elements of commercialisation such as market research, advertising and business planning. Phase II B award recommendations are made within 90 days of the two closing dates for submissions each year.

## 5.3 Solicitations

The NSF has two Phase I solicitations each year, with funding commencing in the following fiscal year. In 2005, there were two solicitations:

(i) Electronics and Security Technology (closed 8th June 2005);

(ii) Biotechnology, Chemical-based Technologies and Emerging Opportunities (closed 8th December 2005).

The range of topics listed within these broad areas is wide ranging and runs to 29 pages for the two solicitations combined. The first of the two 2006 solicitations was published on 13th March with a deadline for submissions of 13th June. The topics this time had different themes: "Information Based Technology, Advanced Materials, Manufacturing Technology, and Emerging Opportunities".

In each case the applicant is invited to propose both the specific problem and the solution on which R&D is to be undertaken. The NSF describes its awards as "grants" reflecting its openness to a wide range of proposals. The examples in Exhibit 5.2 illustrate the range and approach.

*Like all SBIR programmes, NSF awards are made only to businesses. However, the NSF is highly flexible in the way that it treats academic participation in its SBIR and STTR programmes.*

34 The recent decision to amalgamate the National Health Service's R&D activities with the Medical Research Council is a move towards the US approach.

**EXHIBIT 5.2: EXAMPLES OF RECENT NSF SOLICITATION TOPICS**

**Biotechnology**

- New capabilities enabling the massive sequencing of entire genomes of organisms;
- Potential commercial applications of combinational biosynthesis;
- Development of biotechnology based products that may have potential for industrial and/or household use (e.g. industrial enzymes, healthcare related consumer devices);
- Novel and/or improved medical imaging and sensing technologies such as in-vivo molecular and cellular imaging and probes;
- Systems, devices and materials to improve the performance of existing drugs.

**Electronics**

- Non destructive testing and evaluation systems;
- Location aware computing;
- Novel chip architecture involving system on chip designs;
- Sensors – gas sensors, microsensors etc;
- Applications of robotics to manufacturing involving development of next generation, intelligent machines;
- Photonic materials and crystals;
- Organic light emitting diodes;
- Photolithography;
- Manufacturing and integration of RF systems.

**Information Based Technologies**

- Management of "Knowledge Intensive Dynamic Organisations" (e.g. business process improvement, customer feedback and relationship management systems);
- Data mining and management;
- Wireless communications (e.g. software radios);
- Embedded systems;
- Content authoring systems for e learning.

## 5.4 Programme Management and Selection Process

The NSF has a staff of ten SBIR/STTR Programme Managers under its Director of Industrial Innovation, Dr Kesh Narayanan. Dr Narayanan has a doctorate in Materials Science and Engineering from Carnegie Mellon University and held senior commercial technology positions in US materials companies prior to joining NSF.

Project selections are made with the aid of an external peer review process. The verbatim comments of reviewers are made available anonymously to applicants.

## 5.5 Commercialisation

Like all agencies, the NSF has placed increasing emphasis on commercialisation and it has a number of initiatives to assist this. They include a "Matchmaker Programme" to bring a database of extracts of current and completed projects to the notice of corporations and venture capitalists, and the Phase II B bridge funding described earlier.

The NSF's most recent (December 2005 and March 2006) solicitations included a special category – "Emerging Opportunities". These are topics designed to enable the NSF to support IT related projects with near term commercialisation potential (i.e. able to enter the market within 3 years). The selection of awards under this category pays particular attention to the existence of a balanced business team and letters of support from potential customers, partners and investors.

## 5.6 Academic Involvement

Like all SBIR programmes, NSF awards are made only to businesses. However, the NSF is highly flexible in the way that it treats academic participation in its SBIR and STTR programmes.

For STTR awards, the participation of a university or college is mandatory. In this case between 30% and 60% of funding goes to the academic partner and 40-70% to the business. Under SBIR awards, academic participation is optional, with up to 33% of Phase I funding and up to 50% of Phase II funding going to the academic partner, if there is one.

In the case of both SBIR and STTR awards, a university faculty member can:

- be a Principal Investigator (with official leave from his or her university);
- work as a consultant on projects;
- own or have shares in awardee companies;
- participate in a university subcontract.

University laboratories are permitted to undertake analytical and other service support.

To help students and teachers gain some experience of high technology businesses, the NSF also offers a range of supplemental grants to SBIR/STTR companies. These are on top of the normal awards and comprise:

- Research Experience for Undergraduates Grant (REU); typically $6,000 per student; up to 2 students per year per SBIR/STTR award;
- Research Experience for Teachers Grant (RET); typically $10,000 per teacher; up to 2 teachers per year per grant;
- Research Assistantship's for Minority High School Students Grant (RAHSS);
- Minority Serving Research Institutions Grant.

## 5.7 *Success Stories*

### Brewer Science

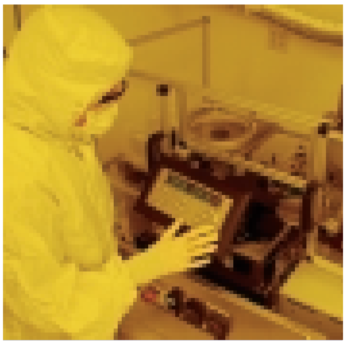

Image courtesy of Brewer Science, Inc.

One of NSF's SBIR success stories is Brewer Science, Inc., based in Rolla, Missouri. Brewer is a leading supplier of specialty chemicals and instruments to the micro- and opto-electronics industries worldwide.

Its technologies can be found in a wide range of products including computers, cameras, video recorders, cellular phones, medical instrumentation, telecommunications equipment, automobiles, and games. They are also used in instrument displays on military and commercial aircraft and in NASA's space shuttle. Formed by Dr Terry Brewer in 1981, the company has received over 40 SBIR contracts from more than six different agencies, including the NSF. Many of these have led to commercially successful products. Today it employs over 300 people, world-wide, and earns more than half of its revenues from outside the US.

*Brewer Science has received over 40 SBIR awards. Its technologies can be found in a wide range of products including computers, cameras, video recorders, cellular phones, medical instrumentation, telecommunications equipment, automobiles and games. They are also used in instrument displays on military and commercial aircraft and in NASA's space shuttle.*

### Altus Pharmaceuticals

Based in Cambridge, Massachusetts and originally named Altus Biologics, Altus was formed in 1993 as a spin-off from Vertex Pharmaceuticals, a NASDAQ listed rational drug design company.

The foundation of Altus' drug discovery business is a catalyst technology it developed under an NSF award in the mid 1990's. In 1996 the National Science Foundation described it as one of the most significant breakthroughs in biocatalysts over the previous ten years. This development provided the platform technology on which the company has built its portfolio of protein based drug candidates.

During its early years Altus also developed a catalyst material to neutralise nerve agents under an Army SBIR programme. In 2003 it won a $750k Phase II award from the National Institute of Health to develop a novel enzyme therapy for the treatment of chronic abdominal pain.

Altus has raised significant amounts of venture capital to finance development of a portfolio of drug therapies for gastrointestinal and metabolic diseases, including a $51 million "C" round in May 2005. Despite its substantial private sector funding, it continued to make use of SBIR contracts.

In January 2006 Altus IPO'd on NASDAQ raising $105m.

## 5.8 Website

Comprehensive information on the NSF's SBIR programme is available at **www.nsf.gov/eng/sbir**

Image courtesy of US Department of Agriculture

# 6 THE SBIR PROGRAMME AT THE UNITED STATES DEPARTMENT OF AGRICULTURE

## 6.1 Overview

The role of the United States Department of Agriculture (USDA) comprises:

- Enhancement of economic opportunities for US farmers;
- Support for increased economic opportunities and improved quality of life of rural America;
- Enhancing the protection and safety of United States agriculture and food supply;
- Improving the United States' nutrition and health;
- Protecting the United States' natural resource base and environment.

The Agency's overall budget is about $95 billion and its total research budget is $2 billion. Roughly $1 billion of this is spent through the Cooperative State Research Education Service (CSRES) which handles most of USDA's extramural research and the SBIR programme.

Over the years USDA's SBIR programme has supported projects ranging from robotics to biofuels. Bioterrorism (e.g. protecting food supplies), homeland security (e.g. protecting water supplies) and agriculturally related manufacturing technologies are particular priorities at the present time.

As one of the smaller agencies, it does not have an STTR programme.

The statistics for USDA's SBIR programme are as follows:

**EXHIBIT 6.1: SBIR STATISTICS FOR USDA**

| | SBIR |
|---|---|
| *Total Programme Budget for Financial Year 2004/05* | $19.3m |
| *Number of Phase I Proposals* | 557 |
| *Number of Phase I Awards* | 93 |
| *Phase I Success Rate* | 17% |
| *Number of Phase II Proposals* | 79 |
| *Number of Phase II Awards* | 40 |
| *Phase II Success Rate* | 51% |

## 6.2 Award Structure

Phase I USDA SBIR awards are for $80,000 and are designed to run for 8 months. Phase II awards are currently for $300,000 and last for 2 years. From 2007 this will be increased to $350,000. No cost, time extensions are available for up to a year for both Phase I and Phase II awards. With repeat extensions, projects can last for up to 5 years. Like other agencies USDA awards are designed to fund 100% of project costs.

## 6.3 Solicitations

USDA has just one solicitation per year. The time-table for 2006/7 is:

- Solicitation topics released: 1 June 2006;
- Deadline for Phase I proposals: 1 September 2006;
- Panels meet in January/February 2007;
- Decisions made by 1 March 2007;
- Phase I award period: 1 May 2007 – 31 December 2007;
- Phase II proposal deadline: 2 February 2006.

There is normally a funding gap of nine months between the end of Phase I and the start of Phase II, though USDA claims that awardees can eliminate this entirely by budgeting carefully and using USDA's pre-award Phase II authorisation provisions.

Topics are defined by broad area and companies are invited to define both the "problem" or "objective", and the R&D programme to address it. Exhibit 6.2 lists the twelve current topic areas, together with short summaries of one of the "suggested" topics within each area.

## 6.4 Programme Management

The USDA SBIR programme is managed by a team of six scientists under the direction of Dr Charles Cleland. Dr Cleland's research career as a plant physiologist included periods at Stanford, Harvard and the Smithsonian Institution Environmental Research Centre. He joined USDA as Director of the SBIR programme in 1987. In 1998 he was awarded a National Tibbetts Award in recognition of his contribution to the Programme.

For the Phase I review a different panel is used for each topic area and an "outstanding research scientist" is selected as topic manager for each review panel. Proposals undergo initial screening and are then assigned to the appropriate topic area. USDA SBIR proposals are reviewed using outside experts from non-profit organisations.

Awards are based on scientific and technical merit though clear commercialisation plans are required as part of a company's submission.

Each proposal is sent to between four and six ad-hoc reviewers who mail in written comments. The proposals are then reviewed by two members of the review panel. Based on the reviews and panel discussions, each proposal is ranked and the top ranked ones recommended for awards.

**EXHIBIT 6.2: USDA TOPIC AREAS**

- *Forests and Related Products (e.g. developing new products or technologies to increase the use of wood)*
- *Plant Production and Protection (e.g. improved plant disease diagnostics, disease resistant speciality crops)*
- *Animal Production and Protection (e.g. development of equipment, facilities or management equipment that promotes animal welfare during production and transport)*
- *Air, Water and Soils (e.g. improved irrigation technologies)*
- *Food, Science and Nutrition (e.g. novel or rapid assay technologies for food constituents, properties or interactions, developing and using information technology to convey important nutritional awareness to the public)*
- *Rural Community and Development (e.g. development of new manufacturing technologies to promote job creation and income growth in the small business sector of the rural economy)*
- *Aquaculture (e.g. novel or innovative approaches to genetic improvement of aquacultural stocks)*
- *Industrial Applications (e.g. development of new agricultural sources of industrial oils and waxes)*
- *Marketing and Trade (e.g. development of innovative real-time/near real-time information systems)*
- *Wildlife (e.g. improved control methods for mitigating the influence of animals on crop plants)*
- *Animal Waste Management (e.g. development of value added products from animal waste)*
- *Small and Mid Sized Farms (e.g. development of tools and skills appropriate for management of small firms)*

The SBIR programme follows the panel recommendations closely, but allocates funds to each of the twelve broad topic areas in proportion to the number of proposals submitted. Proposals recommended for funding also undergo an administrative review prior to the award being made.

The project director of each proposal, whether funded or not, receives the panel summary and verbatim copies of individual reviewers' comments on their proposal, minus the score and name of the reviewer.

For the Phase II review process each proposal is sent to between six and eight ad-hoc reviewers who are experts on some aspect of the proposal. The ad-hoc reviews for all proposals in a given topic area are then sent to the Topic Manager who provides a rank order for proposals based on his or her reading of the ad-hoc reviews and proposals.

These rankings are used to determine which proposals should be funded and the level of the award that should be made. Decisions must then be approved by an internal USDA panel.

The key evaluation criteria for Phase II are similar to Phase I, but put more emphasis on commercialisation and the Phase I results to demonstrate technical feasibility. They include:

- Scientific/technical merit;
- Importance of the problem to American agriculture or rural development;
- Degree to which Phase I objectives were met and feasibility has been demonstrated;
- Impact (local, regional, national and global);
- Commercialisation potential;
- Adequacy of research plan;
- Qualifications of "Principal Investigator" and other key personnel;
- Adequacy of facilities;
- Qualifications of consultants;
- Letters from consultants;
- Adequacy of bibliographies for Principal Investigator and key personnel and consultants.

Phase II awards also take account of any follow-on funding agreements with investors, customers or partners, and the company's prior success in commercialising technologies developed with SBIR support.

## 6.5 Academic Involvement


Image courtesy of USDA Agricultural Research Service

University involvement in SBIR projects is strongly encouraged by USDA. A university faculty member may serve as a consultant or receive a subcontract (both limited to no more than 33% of a Phase I award or 50% of a Phase II award) whilst continuing to work full time at his or her university. University faculty members may also serve as Principal Investigators on projects providing they reduce the proportion of the time they spend on university employment to 49% for the duration of the project and the SBIR research is performed outside their academic research laboratory.

However, it is usually unacceptable for a university faculty member to serve as a consultant on an SBIR project if it is also proposed to undertake all of the research in his or her laboratory.

## 6.6 *Success Stories*

### Embrex Incorporated

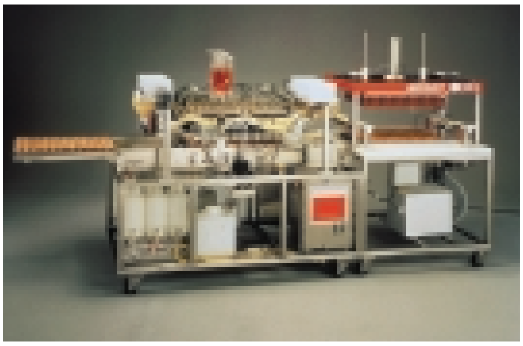

Image courtesy of Embrex Inc.

One of USDA's best success stories is Embrex Inc. Formed in 1985, it won a $49,000 Phase I US SBIR award in the same year; and a $180,000 Phase II award in 1986.[35] The money was used to fund development of 'Inovoject', an automated machine for vaccinating chicks in ovo (i.e. whilst they are in the egg), based on patented technology developed by USDA scientists. The award enabled Embrex to raise significant venture capital and to go on to IPO on NASDAQ in 1991, when it raised a further $16 million.

Inovoject systems are now operating in more than 30 countries and over 70 billion eggs have been injected since the product was launched in 1992. Embrex Inc is a profitable company with revenues of just over $50 million, and has developed a number of other technologies and products, both biological and mechanical, all focused on the poultry industry. In 2001, Forbes Magazine selected it for the second year as one of the 200 best small companies in America.

Don Seaquist, VP for Finance and Administration at Embrex Inc, says: *"What we found is that the SBIR program allows small companies to really leverage funding from the government to get their products to market in a much shorter time-frame than would otherwise be possible, given the capital constraints on very small firms."*

He adds, *"Obviously, the government needs to accept a fair degree of risk in funding these firms, but in our case, they and the US tax payer got a very good deal. Between 1993 and 2002, when the initial patent (to which the USDA had granted Embrex an exclusive licence) expired, we paid royalties back to the US government of $3.5 million."*

### Resodyn Corporation

Image courtesy of Resodyn, Corporation

Founded in 1994, Resodyn Corporation develops and commercialises innovative engineering products, including advanced mixers based on low-frequency, high-intensity sound; thermal spray systems for the application of protective coatings; and bioreactors.

One of Resodyn Corporation's technologies is a production process developed with USDA SBIR funding for converting animal fat and recycled cooking oil into biodiesel fuel. The technology enables this to be achieved at costs which are competitive with traditional diesel. Resodyn Corporation formed a joint venture with an industrial partner and then won its first commercial-scale installation contract. The technology was recently purchased from the joint venture by investors who took it public.

Another commercial success has been the acoustic mixer technology. Resodyn Corporation has created a new company, Resodyn Acoustic Mixers, which is currently manufacturing and selling these mixers for a broad range of applications, marketing the technology in industries ranging from cosmetics and pharmaceuticals to chemical processing and electronics materials formulation.

Resodyn Corporation has made extensive use of the SBIR programme over the years to fund the development of its product portfolio. In the last five years it has won more than $14 million in SBIR awards and $20 million follow-on R&D and product contracts. Amongst other US Government Agencies, the company has won SBIR awards from the Environmental Protection Agency, National Science Foundation, the Army, National Institutes of Health, Department of Commerce, Department of Agriculture and NASA.

Lawrence Farrar, the company's President, says: *"Resodyn Corporation uses the SBIR programme as a mechanism to take high-risk, high-pay-off ideas to market. We continue to compete successfully for SBIR awards, which allow us to develop further applications for our core technologies, and new technology initiatives. The SBIR programme has been an enabling programme in the creation, development and success of Resodyn Corporation – and the catalyst for many entrepreneurs throughout the US."*

## 6.7 Website

Further information on USDA's SBIR programme can be found at **www.csrees.usda.gov/fo/sbir**

35 The size of awards was of course much lower then than it is today.

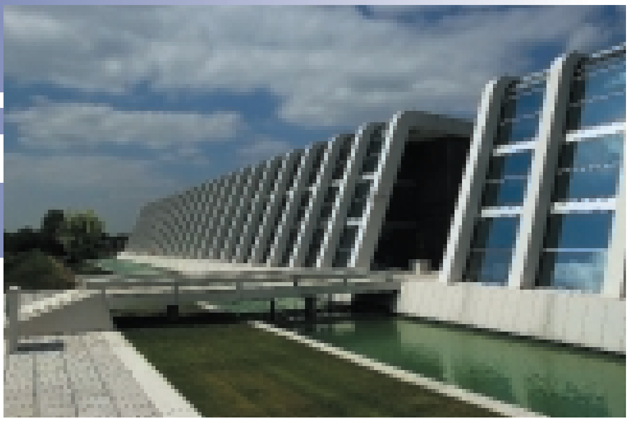
Image courtesy of Trinity College and Napp Pharmaceuticals

# 7 HOW THE SBIR PROGRAMME CONTRIBUTES TO ECONOMIC DEVELOPMENT

## 7.1 Where and How the SBIR Programme Makes an Impact

**The SBIR programme is used by companies ranging from pre-start ups to businesses employing nearly 500 people. It funds the development of technologies for applications in defence to healthcare and it brings benefits to both the small businesses involved and the agencies that fund them. There are many ways in which it contributes to economic development in the US and through which a similar programme could benefit the United Kingdom.**

### Stimulating Innovation in Government Services

The SBIR and STTR programmes help government stimulate the development of new technologies and solutions to help its agencies become more effective and meet their strategic objectives. It does this by the regular processes agencies go through to define and publish perceived requirements.

Innovation is essentially about solving problems. And in business, it is understanding a customer's problems and having the technologies and skills to address them that is the key to developing ground-breaking new products. In many areas of industry customer funding of such developments is common. The SBIR programme extends this practice to the public sector. Its simple approach, with regular solicitations, standardised contracts, and clearly defined time-tables, makes it easier for officials to fund the development of high risk, innovative new technologies than it would be if they had to rely on standard procurement processes.

### Provision of Start up Funding

The programme provides funding for entrepreneurs who are just setting up their businesses, but have neither the time, nor experience to raise private sector investment.

*A similar UK programme would help start up businesses throughout the country, irrespective of their addresses or the existence of local venture capital firms and angel investors.*

Not every potential entrepreneur is in a position to provide for themselves and their family while they look for investors, and their business propositions may not be sufficiently well developed to be "investor ready". It can take nine months to raise venture capital even when a start up has a full management team.

SBIR awards can provide the time and finance to bridge this gap, making stepping out from full time, paid employment to starting a company a much more practical and gradual process than it would otherwise be. Unlike UK R&D grants, SBIR awards require no matching funding, so they are particularly effective in this regard, providing a relatively simple method by which a new business can get underway, without the need for protracted efforts to identify and negotiate with partners or investors. A similar UK programme would help start up businesses throughout the country, irrespective of their addresses or the existence of local venture capital firms and angel investors.

### Facilitating Technology Transfer and University Spin Outs

The SBIR and STTR programmes offer great flexibility to small companies and academics seeking to commercialise technologies developed within a university or government research laboratory.

They provide a way for academics to move gradually from an academic to a commercial environment, for example, by acting as consultants on SBIR projects awarded to small companies.

And for those that want to start their own company, they provide a means of raising money first. Academics, engineers and scientists rarely have the resources to make the kind of high risk financial commitments to a business on day one that would be required without SBIR. Splitting their time between their business and academic research interests, at least initially, is usually the right way forward. A gradual, "soft" start is therefore usually required, and the SBIR/STTR programme provides a means of achieving this.

Whether or not an academic wants to start a new business or exploit his technology and ideas through an existing one, the SBIR programme provides the element of "customer pull" and the mechanism for transferring people, which are so important for successful technology transfer.[36]

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36 Richard Lambert concluded in his December 2003 Review of Business – University Collaboration carried out on behalf of Gordon Brown, that the main challenge for the UK is not about how to increase the supply of commercial ideas from the universities into business. Instead, the question is about how to raise the overall level of demand by businesses for research from all sources.

A Paper by Stephen Allott provides a perceptive critique of the "technology push" approach to university technology transfer policies pursued in the UK in recent years and argues for more "people centric approaches"; *From Science to Growth*, Stephen Allott, Hughes Hall, Cambridge University 2006 City Lecture.

## Supporting R&D that Meets Real Customer Needs

The overall importance of small businesses to the innovation economy is well established. However, it is easy for researchers working in isolation from customers to misjudge market needs, the technical specifications their product must meet to be acceptable, or developments in competitor technologies. Big improvements in product performance may be necessary to win business.

The best market research a technology company can have is a contract to develop something that one of its customers needs. Both private and public sector organisations can play a key role in this process and government procurement represents an important market for many technology companies. For example, the public sector is responsible for purchasing 55% of all information technology products and services supplied in the UK. The solicitations issued by US federal agencies try to identify in some detail their requirements for new technology that will improve their effectiveness or solve problems, thereby increasing the likelihood that small company R&D will be focused on genuine customer needs. As customers they also have the ability to assess the results of that R&D against those requirements, providing further useful feedback as projects progress.

## Signalling to Further "Customers", Partners and Investors

When an early stage company tries to interest customers in its technology, one of the first questions it is asked is "who else is already using your products?". This is one of the "catch 22's" of the start up company. Managers in most large organisations – be they public or private sector – are normally very risk adverse when it comes to buying new technology. From the point of view of personal career risk, they are "better off with IBM". A company that is awarded a SBIR contract immediately obtains some degree of external validation of its technology. As it moves through to completion of a successful Phase II or better still a beta site implementation through Phase III, it has an increasing chance of interesting further public and private sector customers in its products.

Engagement with customers is also one of the key reality checks that any venture capitalist looks for in a small technology company.

## Reducing Time to Market

A closely related issue is the time it takes to interest early customers. Even with very significant new technologies it can take several years to move a lead customer from "interest" to "feasibility study" to "customer trial" to implementation. Indeed, the more significant a technology, the more disruptive it often is to existing ways of doing things, and hence the longer it often takes to get complete "buy in" from across a customer organisation. However, once product sales have started, and the new technology has begun to be accepted by the market generally, competition between suppliers becomes increasingly about the scale of their marketing and R&D budgets (and hence the market share they have built up to finance these "investments"). So the "time to first customer engagement" can have a critical impact on the speed at which a new company can increase its R&D and marketing expenditure, and therefore on its ability to build a substantial global business and retain its independence.

By making an initial award quick and simple, the SBIR programme helps to speed up the overall commercialisation and "business building" processes.

## Easing Access to Government Procurement Budgets

Government agencies are obliged to have a very rigorous approach to procurement. And small businesses often lack the track record and experience to secure contracts when "safer" and more experienced suppliers are inevitably favoured. In the UK "value for money" is a key criteria for selecting suppliers, and officials that do not comply with Office of Government Commerce (OGC) guidelines can find themselves and their bosses under scrutiny by the Audit Commission or hauled up in front of the Public Accounts Committee.

These guidelines are quite inappropriate for funding and trialling high risk, innovative solutions from small technology companies with no track record. If the technology is highly innovative, there may even be no "competitor" with which to make a value for money comparison. Officials trying to fund R&D in such companies find themselves struggling with rules and procedures. In the case of TeraView, a Cambridge company asked to develop a demonstrator of its revolutionary terahertz security screening technology by the UK government, it took six months just to draw up the contract.[37] The simplified and standardised SBIR procedures enable these contractual issues to be dealt with quickly and with certainty.

## Improving Risk Management in R&D

The approach adopted to phasing used in the SBIR programme, with increasing sized phases as milestones are achieved and risk is reduced, is precisely the way that well run commercial organisations stimulate innovation and

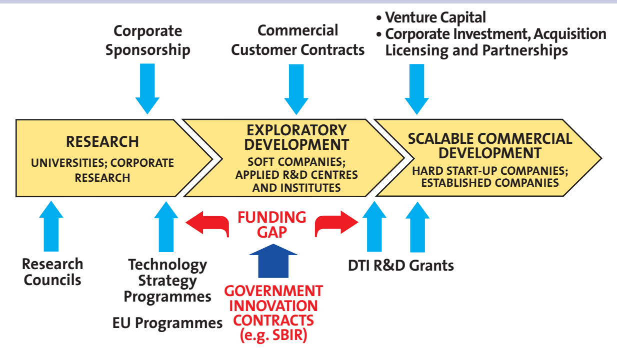
37 This was after an eighteen month delay before government officials were able to identify a budget from which to fund the project. Set against a financing process in which venture capitalists decide whether and at what level to refinance a company roughly every two years largely on the basis of the level of customer engagement, these kinds of delays can have a major impact on business success.

fund their in house developments of new technologies. The early phases can be regarded as the purchase by government of "R&D options". Like all R&D, most projects will fail en route, but a small percentage will lead to widespread take-up by customers. These are the ones on which larger scale Phase III SBIR funding concentrates. By this point projects may also be able to attract private sector investment.

## Exploiting Platform Technologies

The SBIR programme is particularly appropriate for platform technologies. Typically developed within a university or research laboratory, these have multiple potential applications, but very long commercialisation times. Examples of companies based around platform technologies in the UK include Plastic Logic, which is developing revolutionary technology for printing electronics on plastic substrates, TeraView (the world's leading terahertz imaging company) and Metalysis (established to exploit the Cambridge University FFC process for manufacturing a wide range of difficult-to-make metals and alloys). In each case, once the technology has emerged from the academic laboratory a lengthy exploratory period is required whilst various applications are tested and developed in conjunction with customers and partners.

**EXHIBIT 7.1: STAGES IN THE COMMERCIAL EXPLOITATION OF NEW SCIENCE AND TECHNOLOGY PLATFORMS AND UK FUNDING MECHANISMS**




The exploratory process must ideally take place within the commercial structure and disciplines of a business rather than an academic research laboratory.[38] Often the lead applications are in defence or research, where existing solutions fail to meet a high value, specialised and technically demanding requirement. However, it may take some time before the really valuable applications – those where the technology does something significantly better than alternative solutions, and where the sales volumes and profit margins are attractive – become apparent. Only then can a business plan be constructed with a chance of attracting significant levels of private sector investment.

The SBIR programme enables different applications of platform technologies to be developed and tested against a variety of agency requirements, often in parallel. And by providing 100 per cent funding from customers who know what functionality the technology must deliver if it is to beat existing methods, it provides an excellent means of helping to get companies to the point where they have a well focused, ***scalable*** business opportunity to offer venture capitalists.

Neither the collaborative programmes operated by the DTI and EU, nor the DTI's Grants for Research and Development, are appropriate for funding this stage in the exploitation process.[39] And current public sector procurement processes, together with the absence of suitable R&D budgets, also make it very difficult for UK government departments who are potential end user customers to participate in funding the technology developments they need.

## Niche Markets

The SBIR programme is also particularly appropriate to technologies with niche markets. Venture capital investors in early stage science and technology companies need to invest in businesses with potential revenues of hundreds of millions of pounds if they are to be able to compensate for the risks involved and deliver the high returns their own investors demand. And they must concentrate their investments in a small number of such investments so that they can provide the close monitoring and "hands on" management early stage companies require. Specialised companies, with the potential to grow to just a few hundred people, are therefore unlikely to be attractive investments.[40] However, this sector is very important to advanced economies, and such companies can provide the seed beds for much larger companies as their technologies become cheaper and new applications evolve. For example, GPS, once an expensive military technology with a handful of specialist suppliers, will soon be found in every car manufactured.

It is arguable that high volume technology businesses will inevitably gravitate to lower cost, but increasingly technologically sophisticated, nations like China and India, so that strategies to support specialised science and technology companies are crucial to a country, like the UK or US, with a strong science base, but relatively high employment costs.

38 There are very rare exceptions to this. An example would be the Olivetti Research Laboratory (ORL) and its successors, a commercially owned computer laboratory with close links to Cambridge University, founded by Professor Andy Hopper. ORL spun off a series of 'hard' companies following "demonstrator" projects for its corporate partners and shareholders.

39 The UK DTI Grants for Research and Development programme requires significant private sector contributions. It also provides much lower levels of funding than SBIR contracts. Many other government schemes, like The Technology Programme or EU Framework projects require collaboration, usually with academia. The primary beneficiaries are generally the academic members of a consortium. Only a small proportion of the total funding has tended to go to the small business members of consortia and this must usually be matched from company sources. Such projects are ill suited to commercial R&D projects designed to build intellectual property and develop prototypes for customers. It is the author's experience that they are rarely regarded by the small businesses that receive them as significant to their strategies.

40 Businesses that can be sold at very high revenue multiples at this size, because they are still growing rapidly and have "strategic value" to an acquirer are, of course, attractive to VC's.

## Stimulation of "Soft" Companies

"Soft" companies play a key role in the processes by which new technologies are exploited commercially and jobs generated from a nation's science base.

**EXHIBIT 7.2: "HARD" AND "SOFT" START-UP STRATEGIES**


In essence "soft" companies are those whose primary business is carrying out technical consulting and R&D contracts for individual customers, often based around a specialised area of technology, or group of technologies, in which they have world class expertise. And because they are "expertise" based they can mould their R&D efforts to try to solve a wide range of business or public sector problems. In fact whatever the customer needs – providing he or she is prepared to pay.

"Soft" companies require relatively modest amounts of money to get started and growth can often be completely self funded. Their management is mainly about technical project management and selling ideas - skills which any good scientist or engineer has probably had to develop anyway. So for all these reasons they are relatively low risk.

Sometimes soft companies transition gradually into "harder", product-orientated companies addressing evolving niche markets with a significant element of service or customisation. Such transitions can often be financed with little or no injection of development capital from outside.

At the other end of the risk and reward scale are the "hard", product-orientated start-up strategies. Hard strategies are all about an excellent product idea, a strong management team and fast execution ahead of competitors. Significant investment is usually required to develop the product and build a marketing infrastructure before profitability is achieved. But success leads to a highly scalable business than can be grown rapidly, bringing large exit multiples for investors.[41]

"Soft" companies, with their modest rates of growth, are rarely of interest to venture capital firms. They are primarily interested in "hard" companies with tightly focused business plans and highly scalable business models, and which have reached a stage where most of the technical risk has been removed. A pre-requisite of such "execution plays" is a rounded management team with prior experience of the market they are targeting.

However, such opportunities rarely just pop out of the science base. They are much more likely to emerge from the intermediate "exploratory" stage in the exploitation process represented by "soft" companies and other commercially focused applied research organisations. By carrying out a series of R&D contracts around a particular area of technology with different customers, "soft" companies play an important role in trialling different applications, assembling the teams and developing the technology and business proposition to a point where VCs can invest, either directly or through a spin-off venture. Universities simply do not provide an environment where this process can take place efficiently. Cambridge Silicon Radio, which emerged as a spin out from Cambridge Consultants after a ten year gestation period, is a prime example.[42]

In the UK a clutch of broad based "soft" companies, including Cambridge Consultants, The Technology Partnership, PA Technology and Scientific Generics, have been at the heart of the Cambridge Phenomenon, responsible for many spin offs and providing a training ground for project managers, business development directors and venture capitalists. Directly or through this diaspora, they have made a significant contribution to the development of other companies in the Cambridge cluster and beyond.[43]

However their customer base has consisted almost entirely of private sector companies.[44] Government development contracts are a rarity. In the United States there are many soft companies around the country which derive a significant

41 The concept of "soft" and "hard" companies was originated by Matthew Bullock in *"Academic Enterprise, Industrial Innovation and the Development of High Technology Financing in the United States"*, published in 1983. The model was further developed jointly with the author. *"Exploiting the UK's Science and Technology Base: How to Fill the Gaping Hole in UK Government Policy"*, OpCit., gives a fuller description and also includes various examples.

42 Cambridge Silicon Radio plc, which successfully IPO'd on the London Stock Market in February 2004, was built around a team that had carried out a succession of customer funded chip development projects within Cambridge Consultants Limited (CCL). CCL is one of a number of broad based contract R&D businesses in Cambridge that make a living from doing R&D projects for other companies. The core team which founded CSR as a spin-out company in 1999 had worked together at CCL for over 10 years. Its founding team of 9 engineers and commercial managers were joined by additional engineers from CCL during the early months of the company. In the years prior to the spin-out, a series of projects at CCL including, for example, a wireless pager chipset for Ericsson, enabled the team to build a unique capability in integrating digital signal processing and radio frequency applications on to a single chip using standard CMOS manufacturing technology. In setting up CSR the team was able to utilise this approach to develop very low power, single chip Bluetooth designs just as the standard was being adopted by the market place. It was also able to put together a critical mass start-up team. CSR's timing and execution were superb, enabling it to beat some 40 other Bluetooth start-ups from around the world.

43 See *"The Effect of Social Capital in New Venture Creation: The Cambridge High-Technology Cluster"*, Yin M. Myint, Shailendra Vyakarnama and Mary J. New; Strategic Change May 2005.

44 Their customers are typically technology hungry multinationals and they tend to export a very high proportion of turnover.

proportion of their income from federal contracts, with SBIR as the first stage in developing new areas of work. The "success" stories in this report include many examples. They are often very specialised and focused on technologies and markets very different to those of the Cambridge "consultancies". An effective UK SBIR programme would help stimulate a wider range of soft companies in the UK, often linked to specialised centres of academic scientific excellence. This would have both direct and indirect economic benefits to all parts of the UK.

## Increasing the Number of Venture Capital Ready Companies

Any government policy to support the development of private companies must always meet a key test. "Why cannot the private sector play this role?" In this case: "Why cannot the venture capital industry select winners efficiently and provide the early stage funding they require?"

The "equity gap" has been debated for as long as the UK's poor performance at exploiting its science base. But a glance at the statistics on the performance of the UK venture capital industry clearly shows why private sector investors are so reluctant to participate in early stage science and technology businesses in the UK. In reality, over a prolonged period of 20 years, it has demonstrated an inability to deliver average returns for its own investors comparable with other asset classes such as buyouts and investments in other geographies. Whilst there is a range of performance around the average and some VC funds deliver very good performance, the average return has a big impact on professional fund investors' attitudes. Exhibits 7.3 and 7.4 illustrate the problem, and international comparisons with the US, where venture capital (as opposed to buyout) fund returns have consistently been much better than in the UK, reinforce the picture.

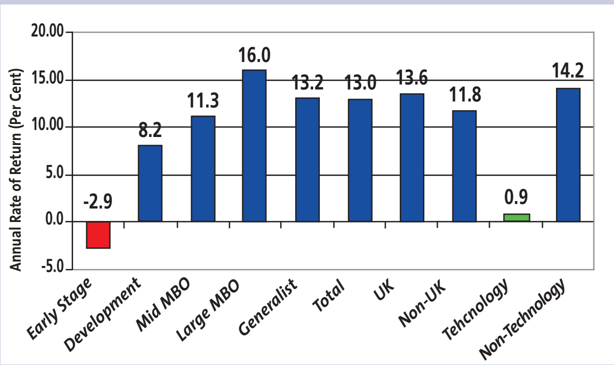
Investment in all of these "alternative asset" classes by pension funds, insurance companies, endowments and high net wealth family trusts is now increasingly channelled through specialised "fund of funds" managers like HarborVest Partners and Allianz Private Equity Partners. Others make use of specialised advisory firms like Cambridge Associates based in Boston, Massachusetts. Sophisticated databases are used to compare performance between geographies and asset classes, and between funds within those asset classes; the aim is to identify top quartile or top decile performers.

The statistics, including international comparisons, show that unless a fund can be **certain** of selecting one of the few top performers in the class (and the long lead times associated with venture capital make this very difficult), early stage technology funds in the UK, and indeed in Europe as a whole, look very unattractive. Venture capital funds in the US or buyout funds in Europe have looked much better bets. As a result there are now very few funds of funds with an active policy of investing in European venture capital.

The entire early stage UK venture capital sector, including established firms with good financial track records, has experienced difficulty in raising the money it needs to continue investing in new companies. There is a widespread belief that this is a structural, rather than cyclical problem. As a director of one of the most experienced firms in the alternative assets community put it, *"You would not propose investing in European (including UK) venture capital unless you thought something was going to change"*.

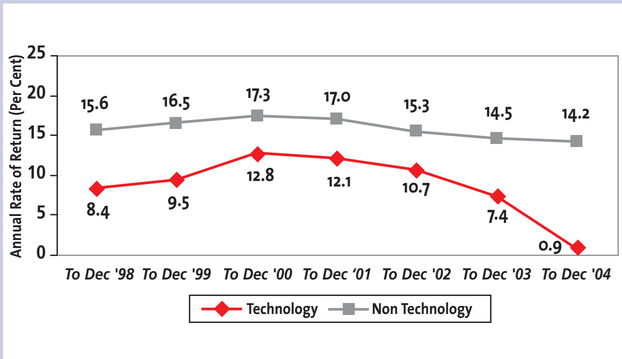
The reasons for the poor performance of the UK early stage venture capital industry are often debated. But in essence it reflects the performance of the company sector in which they invest, and in particular the lack of really big successes of the scale of Amgen or Qualcomm.[45]

**EXHIBIT 7.3: UK PRIVATE EQUITY RETURNS SINCE INCEPTION; PERFORMANCE BY CATEGORY AND SUBSET TO DECEMBER 2004**




Source: British Venture Capital Association

**EXHIBIT 7.4: UK PRIVATE EQUITY RETURNS SINCE INCEPTION; PERFORMANCE BY TECHNOLOGY AND NON-TECHNOLOGY INVESTMENTS**




Source: British Venture Capital Association

45 In the US during the 1990's, 11 venture-backed companies returned over 250 times their VC's original investment. During the same period in Europe, 10 venture backed companies returned more than 20 times. *"Light at the End of the Tunnel?"*, Denis Mortier, Coller Capital, 2006.

The lack of other sources of funding for early stage companies is recognised as one of the underlying reasons for poor UK and European early stage technology VC performance by some fund investors. As Sandra Robertson, responsible for investments in venture capital and private equity worldwide by the Wellcome Foundation has noted; *"In the USA, there is a significant amount of soft funding from government bodies, wealthy individuals and corporations. European entrepreneurs do not enjoy this level of soft funding".*

In fact SBIR and other federal R&D contracts are probably at least as important in value terms as venture capital in the funding of early stage US technology companies. One frequently quoted study by Lewis Branscomb and Philip Auerswald suggests that the US federal government is responsible for providing 20-25% of early stage technology development funding, roughly on a par with the importance of angel finance and between three and eight times as important in value terms as venture capital.[46] The Maine study, summarised in Section 2.8, supports a broadly similar conclusion.

If we continue in the UK to expect VC firms to bear the brunt of financing early stage science and technology companies which are not "venture ready", we will only help them deliver returns which turn off their own investors and reduce the level of genuine private sector venture capital which is available in the UK.

A US style SBIR programme would help improve the health of the UK venture capital industry in two important ways:

(i) it would provide funding and some commercial traction to help take new companies with competitive technology to the point at which they are venture-ready, including providing a period of time over which they can begin to assemble a management team;

(ii) by helping reduce the "time to first customer" it would help accelerate the critical early revenue growth phase so that recipients are better positioned to compete with companies based in the US and elsewhere and more likely to become major global players, and deliver good returns for investors.

> ***"In the USA, there is a significant amount of soft funding from government bodies, wealthy individuals and corporations. European entrepreneurs do not enjoy this level of soft funding".***
>
> **Sandra Robertson, Head of Alternative Assets, Wellcome Trust.**

## 7.2 The Bottom Line

The key measure of performance for any economic policy like SBIR is its impact on jobs and economic growth. Like all such policies, evaluation is complex. It must be remembered that all R&D programmes are risky and the failure rate for new product introduction is high. Venture capitalists are dependent on a small percentage of "big wins" to deliver a positive return on their portfolio and the fundamentals of this investment model remain true even if an SBIR programme helps reduce the level of technical risk entailed. The direct economic benefits of SBIR are therefore likely to be concentrated in a relatively small number of companies. On the other side of the coin there are also many R&D spill over benefits to other firms.

Besides internally funded reviews like that by the National Institutes of Health referred to in Section 4.4, and the consistently positive independent official reviews, undertaken, for example, by the GAO and SBA, there are two other main sources of data on which we can currently draw: academic studies and an analysis by Roland Tibbetts.[47]

The most substantial academic study of the SBIR programme is by Joshua Lerner at Harvard Business School. He has examined 500 SBIR award winning firms in comparison with 900 other matching non SBIR award winning firms over a ten year period. The analysis showed that the SBIR award winning firms had created five times as many jobs as the matching firms over the period (26 jobs per firm as compared with 5 or 6 per firm for non SBIR award winners). The difference was greatest in parts of the country with higher levels of venture capital and high tech entrepreneurial activity; SBIR winning companies there grew 17 times more than non SBIR winning firms.[48]

Interestingly, Lerner found that multiple SBIR award winners faired no better than single award winners in terms of growth. This perhaps illustrates the wide range of positive impacts that SBIR can have on a company. In some cases, like Genentech, one or two awards received while a business is still a small private company can be quickly followed by rapid growth, financed by venture capital and an IPO. From then on the recipient effectively disappears from the SBIR radar.[49] In others, a stream of awards helps stimulate the slow and steady growth of niche players employing a few hundred people each. Many of the success stories in this report fall into this category. In other cases, successful companies become absorbed by larger public corporations and it is difficult to measure the ultimate economic impact. Photobit, described in Section 3.2, is an example.

46 *Between Invention and Innovation; An Analysis of Funding for Early-Stage Technology Development*, prepared for the US Department of Commerce National Institute of Standards and Technology, Professor Lewis Branscomb and Philip Auerswald; November 2002.

47 The most comprehensive attempt to assess the economic impact of the SBIR programme is currently being undertaken by the National Research Council of the National Academies. *Capitalising on Science, Technology and Innovations: An Assessment of the Small Business Innovation Research Program* is a major research effort led by Charles Wessner, launched in October 2002. The results are not yet available, though some preliminary papers on issues and methodology have been published as well as various conference proceedings. See *SBIR: Program Diversity and Assessment Challenges: Report of a Symposium* edited by Charles W Wessner, National Academies Press, Washington 2004, and *SBIR Challenges and Opportunities*, Edited by Charles Wessner, National Research Council, National Academy Press 1999.

48 *Public Venture Capital: Rationale and Evaluation;* Joshua Lerner in; *The Small Business Innovation Research Program: Challenges and Opportunities; Board on Science, Technology and Economic Policy,* National Research Council, National Academy Press 1999.

49 There is, of course, a possibility that this is simply because well managed firms know how to find public money! However, other evidence suggests that this is not the right interpretation.

Image courtesy of TTP Group plc

Even SBIR funded companies that never get beyond doing R&D can provide a training ground from which more ambitious and commercially aware managers can step out to start their own firms.[50]

So perhaps we should look more towards a broader "score sheet" approach, such as that presented at a conference in 1998 by Roland Tibbett.[51] As architect and godfather of the SBIR programme, and previously a private sector entrepreneur and venture capitalist, he has enormous knowledge of the SBIR programme's evolution and impact, though we must of course remember that this means his perspective may not be completely unbiased.

Roland Tibbetts served as SBIR Programme Manager at the National Science Foundation from the inception of the SBIR pilot programme in 1977 until his retirement in 1992. Before leaving the NSF, he reviewed the impact of 50 NSF SBIR awards made over his career for which the award winner attributed at least $2m in subsequent sales to the SBIR award. The companies are each described in his paper. Subsequent research in 1996 concluded that:

- 16 of the 50 firms believed the NSF SBIR projects were key to their starting the company;
- 45 of the 50 firms believed the SBIR projects were critical to their growth or survival;
- cumulative total sales of $2.2 billion were judged to have been **directly** attributable to the NSF SBIR projects and a further $6.9 billion was indirectly related to SBIR research or funding from NSF – i.e. the product involved would not have been developed without an NSF SBIR project. The total attributable cumulative sales ranged from $2m to $2 billion per company;
- 34 per cent of the 50 companies' revenues came from exports;
- private sector follow on investments into the companies totalled $963m, of which $527m was directly related to the NSF project and $436m was indirectly related;
- the most valuable benefit to companies of the NSF SBIR award was that it funded an idea for which they had otherwise been unable to attain funding;
- the combined employment of the 50 companies had increased from 527 at the time they submitted their first successful SBIR proposal to 11,500 in 1996. Of these, 9,079 jobs were with the SBIR firms or its successor and 436 were with related joint ventures or spin offs, giving an overall growth in employment of 2,100 per cent;
- the 50 companies had been granted 377 US and 732 foreign patents that related directly or indirectly to SBIR research or funding;
- in 1996 the firms were undertaking 959 research collaborations including 404 with industrial firms, 394 with universities and 111 with national laboratories;
- most of the 50 companies interviewed said they expected SBIR related sales, investment and employment to increase each year into the conceivable future, often at a faster rate because they had obtained private financing and market acceptance;
- the 50 companies identified significant SBIR funded technological innovations leading to commercial products in all major areas of science and technology within NSF's remit.

So whilst both Lerner's and Tibbett's analyses pose further questions, and we can never know what would have happened without an SBIR programme, the evidence is overwhelmingly that the "bottom line" is well into the black.

***A review of 50 National Science Foundation award winners showed that additional sales of $2.2 billion were directly attributable to technology developed under SBIR funded projects. Their employment had grown from 527 to 11,500.***

50 This process is clearly visible within technology clusters such as Cambridge. Academic studies of "R&D spillovers" quoted by Lerner suggested that the gap between the private and social rate of return to R&D investments by firms is probably equal to 50% to 100% of the private rate of return, with small businesses being particularly subject to large discrepancies; Lerner; Op.Cit.

51 *The Small Business Innovation Research Program and NSF Commercialisation Results*; Roland Tibbetts; *Conference on SBIR Challenges and Opportunities, Board of Science, Technology and Economic Policy*, National Research Council, National Academy of Sciences 1999.

Image courtesy of TTP Group plc

# 8 A BLUE PRINT FOR UK POLICY

## 8.1 The Story So Far

**Whatever weight one places on studies to measure the economic impact of the SBIR and STTR programmes in the US, one fact is indisputable. It is virtually impossible to find anyone in either the US public or private sectors who does not believe they play a key role in the national innovation system. Where there are criticisms they are mainly concerned with details of implementation, rather than principle, and over the years various improvements have been made to address them. There is wide support for a similar programme in the UK and an active campaign for legislation.[52]**

As we have seen, through the SBIR and other programmes, US early stage companies have access to Government R&D funding at a level which is probably an order of magnitude larger per company than in the UK. As a source of early stage capital, the SBIR programme is probably at least as important in value terms as venture capital. Unlike most venture capital, SBIR awards are available from right at the start of a business's life.

Attempts by the UK to emulate the US scheme have so far been unsuccessful. In 2001,the UK government introduced a similarly named programme called the "Small Business Research Initiative" (SBRI). It aimed to provide a web portal where government departments could advertise R&D contracts. The objective was for 2.5% of external R&D to be spent with SMEs through this mechanism, with an overall target of £50m. However, virtually no government departments participated and, up to 2005, it only ever advertised contracts worth around £2m per year.[53]

In response to lobbying pressure the Chancellor announced in his March 2005 Budget that in future there would be a mandatory requirement for all departments to spend 2.5% of external R&D expenditure with SME's - a commitment believed to be worth £100m per annum. However, the government did not establish an SBIR "process", the key factor in its success in the US, and so the campaigners have continued to lobby for legislation. Despite subsequent changes to the UK SBRI introduced by the Small Business Service (SBS) in April 2006, it still bears little or no resemblance to the US SBIR programme.[54]

This is perhaps not surprising. If it is to encourage spending departments to use procurement to stimulate innovation, government needs to bring about a major culture change within them. It must also address the conflicts between departmental objectives that arise from Office of Government Commerce procurement rules and Treasury budgeting systems. And it must steer a careful route through EU regulations.[55] This is far too difficult a coordination job for the SBS, and its lack of practical experience of science and technology management makes it ill equipped to take it on.

In the United States, the creation of the SBIR legislation was a catalyst for kick starting the necessary culture change and overcoming opposition from spending agencies. The role that small businesses play in innovation and economic development is now recognised across government and many participate actively in non SBIR contracts.

Part of the problem in the UK seems to be a fundamental difference in the way that government departments see their responsibilities in relation to innovation compared with their US counterparts. Spending departments' R&D activities seem to have become increasingly focused on scientific policy advice, operational research and longer term academic research. There is a view that innovation is not their responsibility, but that of the private sector and DTI. In contrast, US federal agencies regard it as a key part of their role to stimulate and finance innovative R&D which will help them achieve their strategic goals and improve their effectiveness. To achieve the same result in the UK, we must either adopt a similar legislative approach or ensure that policies are backed and monitored from right at the top of government. The elements of a programme that could help bring about this change are set down below.

52 In December 2004, following meetings with government at both ministerial and senior official level, the author launched a campaign with Anne Campbell (then MP for Cambridge) to persuade the government to bring in a US style SBIR programme. After the May 2005 election, the political baton was taken up by Kitty Ussher, MP for Burnley. Mrs Ussher was previously a Special Adviser at the Department of Trade and Industry. The campaign has been backed by many high profile scientists, entrepreneurs and venture capitalists, some of whom signed a letter of support to the Financial Times on 19th October 2005.

53 The key exception was the Biotechnology and Biological Sciences Research Council which ran a small programme each year closely based on the US model. The size of awards were relatively modest by SBIR standards, but the scheme seems to have been well regarded by beneficiaries and it demonstrates that such a programme is possible in the UK.

54 The SBS's new approach is limited to encouraging departments to participate in the Supply2.gov.uk website and the monitoring of undemanding departmental targets for R&D spending with SMEs.

The Supply2gov.uk website is limited to contracts under £100k, whereas individual US SBIR projects are normally for approximately £500k.

The SBS monitoring approach requires departments to provide annual returns showing the percentage of R&D expenditure with SMEs. Not surprisingly the first return shows that they already spend more than 2.5% of their R&D with small businesses, with the overall picture being dominated by the MOD. There is no information available to show how these figures have been compiled. In fact, 2.5% is not a demanding target. As we saw in Chapter 2 of this report, in the US 13% of federal R&D contracts by value go to small businesses. The 2.5% set aside for SBIR, and more importantly the structure and programme management processes that go with it, just provides a mechanism to help small companies take a first step on the procurement ladder. By interpreting the Chancellor's 2.5% figure as a target for the TOTAL share of external R&D spent with SMEs, the SBS has inadvertently undermined the whole principle of the initiative.

55 For many years, the Civil Service had advised the government that introducing a US style SBIR programme could not be established in the UK without breaching EU regulations. Both State Aid and Procurement regulations have been cited as problems. However, a programme based on contracts for R&D projects that government departments require clearly cannot qualify as a "State Aid" ,and the author contends that with care it should be possible to develop processes which deliver the fundamental benefits of the SBIR programme without breaching EU procurement rules. One of the objectives in drafting the Private Members' Bill was to define such a process in detail. A first reading of the Private Members' Bill earlier proposed by Anne Campbell was given in the House of Commons by Kitty Ussher on 7th February 2006.

## 8.2 How a US Style SBIR Programme Could be Established in the UK

### Programme Aims

The aims of the programme should be as follows:

(i) to facilitate the identification of requirements for innovative new technologies with the potential to enhance the effectiveness of government departments and agencies in meeting value for money and strategic objectives, and;

(ii) to facilitate the solicitation and commissioning by government departments and agencies of "Innovation Contracts" with industry for the development and trialling of technologies and solutions capable of meeting those objectives.

### Key Programme Principles

It is not actually possible under EU legislation to restrict a procurement programme to SMEs. However, neither is it necessary. In the US, though companies with up to 500 employees are eligible to participate in SBIR programmes, the majority of contracts go to businesses employing less than 25 people - largely a reflection of the importance of small businesses in the innovation economy. By applying strict criteria for selecting UK award winners based on the level of innovation involved, it is to be expected that the same pattern would emerge. A few highly innovative new ventures within larger companies might also receive awards, but there is no reason why this should reduce the benefits of the programme.

In order for a UK initiative to be as effective as the US SBIR programme it is essential that it provides 100% funding for projects, with contracts awarded in phases to manage risks. It must also have defined timetables for solicitations and awards. And special procurement guidelines and contractual terms must be designed which are appropriate for high risk R&D projects based on novel technology. The term "Innovation Contracts" has been coined for these to distinguish them from conventional procurements of products and services for which the OGC's standard procedures are designed.

Innovation Contracts should only be available for the development and trialling of innovative technologies and solutions. They should not be available for R&D projects associated with improvements to products or product categories already on the market – or at least, not unless significant technical risk is associated with the development and testing required.

Policy studies and research projects directed towards the humanities and social studies should also be excluded.[56] All major departments, including the Research Councils should participate.[57]

The size of individual Innovation Contracts should reflect the amount and cost of the work entailed. Statements by DTI officials repeatedly underestimate both the amounts required per R&D project to match the level of funding offered to small businesses by the US SBIR programme and the cost of funding meaningful technical developments in companies. Based on the US model, it is proposed that projects should typically be for £575k in two phases: an initial feasibility study phase (typically worth £75k) and a larger second phase covering technology development and customer/specifier evaluation (typically worth £500k). Firms should be able, as in the US, to win and undertake multiple awards in parallel.

Departments should be responsible for running their own programmes, but guidelines incorporating these considerations should be issued, administered and monitored centrally. It is arguable that the Office of Science and Innovation would be more appropriate to discharge this role than the Small Business Service, which lacks expertise in the management of innovation and R&D.

### Programme Operation

The programme would operate in a similar way to the US SBIR programme; the process proposed is illustrated schematically in Exhibit 8.1. Its key features are summarised below:

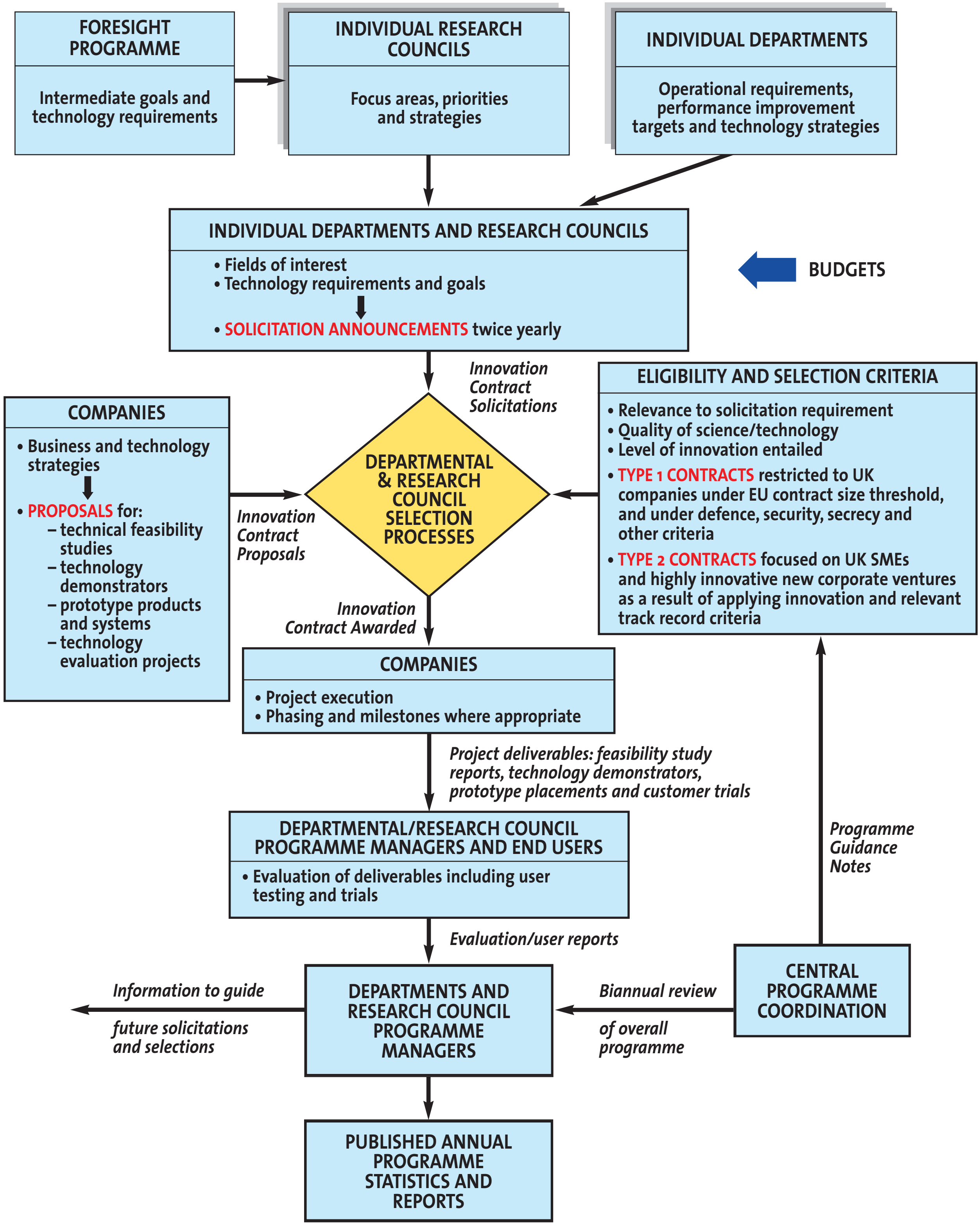
- Budgets for each participating department should be identified at the start of each year;
- Each department should advertise twice a year, via the SBRI website, a list of topics on which proposals are sought. The number of topics advertised each year should be broadly similar to the number of Phase I awards made;
- Topics should take into account the department's objectives and technology strategy, together with the likely timing of commercial implementation;[58]
- Contracts should be awarded solely for:
  - technical feasibility studies;
  - technology demonstrators;
  - prototype products and systems;
  - technology trials and evaluation projects.

56 Such projects entail little or no technical risk and do not lead to scalable new product businesses. Moreover, departments are already quite used to placing such contracts with small commercial firms.

57 Small US science based companies receive significant SBIR funding from the NSF and NIH. The DoD also provides significant funding for scientific research in universities and its exploitation through small companies. For the UK to match this level of support, the UK Research Councils need to perform a similar role. There is an obvious requirement in the area of scientific instrumentation, where small businesses, often themselves university spin outs, can build significant global market shares in niche markets. Such businesses must find a lead laboratory to help specify and pilot new instrument developments, and it is not clear who in the UK can fund such developments if not the Research Councils. There is very strong anecdotal evidence that at present they do not see this as their role and that they lack the mechanisms to do this effectively.

58 Projects for which commercialisation is unlikely within, say, 7 years are probably more appropriate for a university department; it is important that Innovation Contracts do not merely provide another source of funding for academic research. At the same time, projects leading to commercialisation within, say, 18 months are probably insufficiently innovative. Clearly this is an area where judgement would be required.

EXHIBIT 8.1: SUMMARY OF PROCESS FOR DEFINING AND AWARDING INNOVATION CONTRACTS



- Proposals should be submitted within three months and awards should be made within a further three months;
- Contracts should be in two phases:[59]
    - feasibility stage (averaging £75k for 6-9 months work);
    - development stage (typically £500k covering up to 2 years work).

Phasing of R&D projects is an essential part of managing risk. The precise approach needs careful structuring to ensure that it is consistent with EU regulations, but de minimis levels and other features of the regulations make this quite feasible.[60]

- A simple, standardised "Innovation Contract" should be designed with terms and conditions that are appropriate for this type of procurement rather than the OGC norm. IP generated should belong to the awardee;
- Special OGC procurement rules should be defined for these projects permitting rapid contract awards without normal competitive tendering and "value for money" requirements;
- The process of advertising and awarding contracts should be completely transparent, in terms of topics, recipients of awards and the value of individual contracts;
- The aim should be for around 15-20% of applicants to win Phase I awards and 50% of Phase I awards to go on to Phase II. The selection criteria for Phase I contracts should comprise:
    - relevance to the awarding body's aims and objectives;
    - relevance to the awarding body's technology strategy;
    - the level of innovation entailed;
    - the quality of science and technology;
    - the company's record in carrying out previous Innovation Contracts, if any, taking account of the level of risk associated with research and development projects.

For selection of Phase II contracts the following additional criteria should also be taken into account:

- the probability of the company's meeting the requirements specifications, assessed according to previous successful contracts in the relevant field;
- the likelihood of commercialisation, further research and development funding from a third party, or subsequent purchases or research and development funding.

- Phase II awards should be made no more than 12 months after the start of the Phase I awards to which they relate;
- Rules for the involvement of academics as sub-contractors should be established similar to those for the US SBIR programme;
- The effectiveness of the programme should be reviewed every two years.

Image courtesy of Diagnostics for the Real World Ltd

## Budgets

Figures recently published by the SBS show that sticking strictly to a 2.5% set aside for each department is inappropriate. The MOD is responsible for 83% of all government external R&D (62% if the Research Councils are included), whilst at the other end of the scale, some important departments have R&D budgets which are too small for the 2.5% rule to finance viable programmes. Individual departmental budgets should therefore be established that reflect the perceived scope for technological innovations to improve their effectiveness or meet their policy objectives.

The budgets in Exhibit 8.2 provide a rough indication of what might be an appropriate breakdown between departments, assuming an overall budget of around £100m per annum. It also shows the number of innovation projects that would be funded. Overall, a programme of this kind would each year fund around 300 Phase I feasibility projects at an average cost of £75k per project and 150 Phase II demonstrator/customer evaluation projects at an average cost of £500k per project. It is reasonable to assume that 50-70 of these projects might go on to generate further commercial revenues for the companies concerned and/or lead to the SMEs involved raising private sector investment for further development. The multiplier effect through private sector involvement and jobs has the potential to be significant.

The cost of the programme outlined in Exhibit 8.2 would be £23m in year 1, increasing to £99m a year thereafter as Phase I projects move to Phase II. To speed up implementation it would probably be appropriate for the programme to be pump primed with new money. Subsequent departmental budgets for innovation contracts should be ring fenced each year.

It is important to note that in the US successful Phase I and Phase II SBIR projects are frequently followed by Phase III R&D contracts from mainstream (i.e. non SBIR) agency R&D budgets and/or the procurement of developed product. UK government departments need a similar capacity to follow through when appropriate.

59 The US SBIR programme defines three phases, but Phase III projects are funded from outside the SBIR budget.

60 *To avoid breaching EU Procurement Regulations*, the Kitty Ussher/Anne Campbell Private Members' Bill was originally drafted by the author to allow phasing **implicitly**, rather than explicitly.

**EXHIBIT 8.2: PROPOSED INDICATIVE DEPARTMENTAL BUDGETS FOR INNOVATION CONTRACTS ***

| | Proposed Budget for Innovation Contracts (£m)* | Notes | Number of Phase I Feasibility Studies Per Year | % Reaching Phase II (£k) | No of Phase 2 Demonstrator/ Technology | Av. Value of Phase II (£k) Evaluation Projects |
|---|---|---|---|---|---|---|
| *Department for Environment, Food and Rural Affairs (DEFRA)* | 5 | | 16 | 50.0% | 8 | 500 |
| *Department for Education and Skills (DfES)* | 3 | | 8 | 50.0% | 4 | 500 |
| *Department for International Development (DfID)* | 0 | | | | | |
| *Department for Transport (DfT)* | 5 | | 16 | 50.0% | 8 | 500 |
| *Department of Health (DoH)* | 20 | | 62 | 50.0% | 31 | 500 |
| *Department of Trade and Industry (DTI)* | 4.5 | Energy | 14 | 50.0% | 7 | 500 |
| *Department of Work and Pensions (DWP)* | 0 | | | | | |
| *Food Standards Agency (FSA)* | 0 | | | | | |
| *Home Office* | 5 | | 16 | 50.0% | 8 | 500 |
| *Health and Safety Executive (HSE)* | 0 | | | | | |
| *Office of Deputy Prime Minister (ODPM)* | 0 | | | | | |
| *Ministry of Defence (MOD)* | 32 | | 98 | 50.0% | 49 | 500 |
| *Research Councils (Inc MRC)* | 20 | | 62 | 50.0% | 31 | 500 |
| | | | | | | |
| *IT Projects For Administrative Departments *** | 4.5 | | 14 | 50.0% | 7 | 500 |
| TOTAL | 99 | | 306 | | 153 | |

* Assumes the average value of contracts is £75k for Phase I awards and £500k for Phase II awards.

** Departments with major administrative functions have a continuing need for innovative information technology systems to improve effectiveness. A separate budget is proposed here to reflect this.

## Making Implementation Happen

Conflicting departmental objectives make the initial implementation of these proposals challenging. And the small amounts of money involved, compared with other departmental expenditures, is itself a barrier. Initiatives of this size command relatively little attention and are all too likely to be submerged within other discussions or programmes. Despite the great emphasis placed on science and innovation policy by the current government and the multiplicity of advisory bodies, few actual policy makers have any practical experience of industrial research and development, innovation or technology commercialisation.

There is little serious interest in the subject from the media, and few votes from today's electors.

Yet the way we foster and exploit innovation as a nation today sits at the very front end of the economic development processes that must safeguard our future standard of living and way of life. Many of tomorrow's jobs depend on getting this right today.

Sponsorship from the top of government is therefore essential to kick start the necessary changes; and the active involvement of the Treasury Spending Review Team and OGC at the start are essential. To help push through implementation, a small steering group would need to be established with representatives from both public and private sectors.

The government has rightly put great emphasis on strengthening the UK's science and technology based businesses and it has set a goal that R&D expenditure (by industry and government) should be increased from the current 1.9% of GDP to 2.5% by 2014. Most, if not all, of the advanced nations of the world have similar goals, a response to growing economic competition from China, India and other countries with low cost, but highly skilled and educated work forces. Many, including Sweden, the United States, Japan and Germany already exceed the UK's target.

But the UK has a history of exploiting its science base poorly which goes back many decades. Merely re-varnishing the policy deckchairs will not achieve the transformation everyone wants. Much more radical policies are needed which reflect the realities of building new businesses to exploit our science base against competition from China and India on the one hand, and the United States and Japan on the other.

**The US SBIR programme is one of the most successful and best regarded of such policies, and it comes from the nation which is probably the most successful of all in building science and technology industries. We would do well to study and imitate it.**

## APPENDIX : US SBIR RELATED WEBSITES

### *Federal Government Sites*

| | |
|---|---|
| Small Business Administration | **http://www.sba.gov/SBIR/** |
| The SBIR Network | **http://www.sbir.net/** |
| SBA Tech-Net (Federal site aiming to list all SBIR and STTR awards, but not yet complete) | **http://tech-net.sba.gov/** |
| SBIR Interactive Technical Information System (SITIS) | **http://dtica.dtic.mil/sbir/index.html** |

### *Participating Federal Agencies SBIR Sites*

| | |
|---|---|
| Department of Agriculture | **http://www.csrees.usda.gov/funding/sbir/sbir/html** |
| Department of Commerce | |
| National Oceanic and Atmospheric Administration | **http://www.ofa.noaa.gov/~amd/sbirs/sbir.html** |
| National Institute of Standards and Technology | **http://patapsco.nist.gov/ts_sbir/** |
| Department of Defense | **http://www.acq.osd.mil/sadbu/sbir** or **http://www.dodsbir.net** |
| Defense Technical Information Center | **http://www.dtic.mil/dtic/sbir/** |
| Air Force | **http://www.afrl.af.mil/sbir/index.htm** |
| Army | **http://www.aro.army.mil/arowash/rt/sbir/sbir.htm** |
| Defense Advanced Research Projects Agency (DARPA) | **http://www.darpa.mil/sbir/** |
| Defense Threat Reduction Agency (DTRA) | **http://www.dtra.mil/acq/business/acq%5Fsmallbus.html** |
| Missile Defense Agency (MDA) | **http://www.winbmdo.com/** |
| Navy | **http://www.navysbir.com/** |
| National Geospatial-Intelligence Agency (NGA) | **http://www.nga.mil/portal/site/nga01/index.jsp** |
| Office of the Secretary of Defense (OSD) | **http://www.acq.osd.mil/osbp/sbir/solicitations/sbir052/osd052.htm** |
| Special Operations Command (SOCOM) | **http://soal.socom.mil/index.cfm?page=sadbu&sb=sbir** |
| Department of Education | **http://www.ed.gov/programs/sbir/index.html** |
| Department of Energy | **http://www.science.doe.gov/sbir** |
| Homeland Security Advanced Research Projects Agency (HSARPA) | **http://www.hsarpasbir.com** |
| Department of Transportation | **http://www.volpe.dot.gov/sbir** |
| Environmental Protection Agency | **http://es.epa.gov/ncerqa/sbir** |
| National Institutes of Health | **http://grants1.nih.gov/grants/funding/sbir.htm** |
| National Aeronautics & Space Administration | **http://sbir.nasa.gov** |
| National Science Foundation | **http://www.nsf.gov/eng/sbir/** |

### *Private Sector or Industry Associations*

| | |
|---|---|
| SBIR Gateway | **http://www.zyn.com/sbir/** |
| Small Business Technology Coalition | **http://www.sbtc.org** |
| InKnowVation Online (Subscriber Database of SBIR Awards) | **http://www.inknowvation.com** |
| National SBIR Conference Center | **http://www.sbirworld.com/** |

## FUTURE CBR RESEARCH

The research for this report has also highlighted much broader differences between the way that the UK and the US defines and manages its government R&D programmes and their interaction with private industry through the procurement process. The Centre for Business Research at Cambridge University is therefore starting a research programme from mid 2006 to examine these broader differences and to study their impact on the processes by which scientific developments are converted into commercial products and economic growth within a modern innovation economy.

The UK policy framework is partly defined by a precompetitive collaboration model established a quarter of a century ago and by European Union policies on state aids and procurement. The underpinning principles which determined this approach were primarily concerned with European integration and a desire to limit wasteful competition as regards national subsidy levels. The policies and programmes we have to support innovation and technology transfer in the UK are largely a result of a whole series of incremental changes and initiatives made against this background over the intervening years.

The purpose of this new research will be to stand back from the detail and from traditional UK policy frameworks in order to undertake a "zero based" review of UK policies, using the very different US approach and those of other countries as comparators. The aim is to help define the R&D and technology exploitation policies that will best sustain Britain's position as a medium sized, high income, innovation based economy capable of meeting the global challenges we will face as the 21st century unfolds.

# "SECRETS" OF THE WORLD'S LARGEST SEED CAPITAL FUND

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