REVIEW OF BUSINESS SUPPORT RELATED CIVIL SPACE ACTIVITIES

A report to the Department of Trade and Industry

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1 Introduction

The remit

1.1 This report draws together the findings and recommendations from a research study commissioned by the DTI working with the BNSC[1]. The work was undertaken by consultants SQW Limited working with academics from SPRU at the University of Sussex. The work focussed on 5 programmes that help UK firms to undertake research and/or development work in connection with the space-related activities [2]. The programmes' combined relevant expenditure (over a period of 4 years for the ESA programmes and 5 years for BNSC's) amounted to a total of approximately £75 million.

1.2 The programmes are as follows:

- BNSC Satellite Telecoms Programme (Satcomms*)* – which provides 50% funding to position UK business in bidding for ESA contracts and to demonstrate their results
- BNSC National Earth Observation Programme (EO) - with the same funding contribution and objectives but in the EO sector
- BNSC Applications Technology Support (ATS) – with the same funding contribution and objectives but for more general business & technological developments
- ESA ARTES 3 & 4
  - *ARTES 3* – 50% grants for development of satellite technology in delivering multimedia systems – specifically Astrium's Ka Sat multimedia satellite mission
  - *ARTES 4* – 50% grants for projects in satellite telecoms – available to a range of space communications' businesses
- ESA General Support Technology Programme (GSTP) – 50% funding for a wide range of projects to enable firms to participate in ESA effectively – e.g. small satellite construction, IT/software for on-board satellite applications.

[1] The reference here is to the staff in BNSC headquarters, elsewhere in the text the abbreviation BNSC (unless specifically qualified) refers to DTI space interests managed through BNSC.

[2] Initially 6 programmes were identified, but it was subsequently decided that the ESA InfoTerra/TerraSAR programme was insufficiently advanced to provide useful evidence

[5] Business support is support that the DTI provides to businesses or intermediaries in order to achieve its high level objectives, with a particular focus on raising UK productivity.

1.3 Our overall remit was to strengthen the evidence base for business support-related civil space activity.[5] Specifically a set of questions was posed that should be addressed in the work programme. The full invitation to tender is attached at Annex A to this report, but somewhat re-ordered, the questions asked were:

1 what have been the past trends in space technology and user markets and how are these likely to develop in future?

2 where are the UK's relative strengths and weaknesses in the exploitation of Space?

3 how well placed are UK based firms or institutions to exploit these trends?

4 what market failures affect different programmes, technology segments or markets (including an assessment of relative severity)?

5 to what extent does the UK-based space industry generate benefits to sectors that trade technologies with the space industry?

6 where do DTI funded programmes offer the greatest potential for generating additional economic benefits?

7 how could DTI make changes to existing programmes or reallocate existing spending to maximise the economic benefits from Space investments.

1.4 It was specified that the search for evidence should address these questions first by analysis of existing academic, market and evaluation material and second through a rigorous programme of new fieldwork. Within the resources available it was apparent that new fieldwork could not seek to address all these questions and the design of the research methodology was, therefore, discussed closely between the consultants and steering group to ensure that attention was addressed to topics on which evidence was especially weak.

Structure of our report

1.5 This report draws on four modules that are presented as free-standing documents in a technical report. They cover:

- methodology
- space industry context
- upstream results
- downstream market applications.

1.6 The scope of this search for evidence was unusually wide in comparison with what would normally be considered appropriate for a programme evaluation. This reflects some differences of emphasis within our client body as to what factors should be taken into account (and what weight they should be given) when formulating suggestions for improvements to the support framework. This issue of the appropriate breadth of the factors to be included was not resolved during the course of our work and we have, therefore, adopted the expedient of presenting, in modules 2, 3 and 4, a full coverage of the evidence garnered during our work irrespective of whether or not some might regard it to be especially germane.

Thanks

1.7 The core of the UK space industry comprises a small number of firms. As the methodology section of this report explains, we sought to avoid making unreasonable demands on firms and individuals. Some were, nonetheless, involved in several detailed and lengthy interviews. We are most grateful for their assistance, nor least because of the demands made on them from other reviews being undertaken during the same period.

2 Methodology

Overall approach

2.1 For most programmes that provide support to individual firms, the justification centres on so called 'market failures' which usually arise from one or more of the following:

- asymmetric information
- technical risks and uncertainties
- externalities – e.g. the creation of benefits that cannot be captured by the firm itself (these are sometimes called 'spillovers').

2.2 For the space industry there are further specific considerations that may be educed to justify public support:

- certain emerging markets are dominated by government demand and/or still being shaped by government regulation; both are fickle and subject to questionable motives such as the desire to create monopoly positions through control of crucial infrastructure or the creation of trade barriers
- space firms in other countries are subsidised so intervention could, <u>in principle</u>, be justified to level the playing field
- the UK contributes to ESA programmes and has specific strategic national objectives in the nature of corresponding procurement contracts won by British-based firms.

2.3 As this last point has a significant bearing on BNSC's programmes it may be helpful to set out how we understand the logic that lies behind it, which is that:

- as a result of contributions to ESA there is a managed market for UK suppliers to ESA created through a juste retour formula.
- it is in the UK interest to ensure that our firms secure business relating to technologically demanding products and services rather than routine items, because of the various benefits that are higher in the former than the latter. Some accrue to the firms themselves in terms of accreting expertise and (probably) valuable business relationships. Others are not captured by the firms and accrue to the wide economy
- other countries contributing to ESA are also concerned that their firms engage in the '*more interesting* ' contracts and give them subsidies that enable them to develop their

expertise in ways that will equip them to compete for such contracts. UK intervention is justified on the basis of practical considerations to level the playing field.

2.4 In seeking out the evidence to help review this rationale, we were asked to explore both the considerations that would apply to any support programme: such as whether the technologies generated by projects led to external benefits which cannot be appropriated by firm undertaking the project; or whether the technologies helped to create new markets (see Annex 1 for a detailed discussion). Thus we considered both the creation of space assets 'upstream' and the use of space assets 'downstream'. The upstream impacts were explored through tracking the impacts from specific projects supported under the programmes. The downstream impacts were explored though consideration of the literature and an extensive programme of interviews.

Methodology for the upstream benefits

2.5 In order to track the impacts of specific projects supported under the 5 programmes a random sample listing was drawn from a population of all projects involving a contract of £100,000 or more and not described under terms such as 'report, marketing, management, conference and CD ROM'.

2.6 The number of projects interviewed for each programme was weighted by the proportional share of the programme's relevant projects in the overall expenditure. Overall 22 interviews were undertaken, 8 for BNSC Satcomms, 2 for BNSC EO, 7 for BNSC ATS, 4 for ESA Satcomms and 1 for ESA GSTP. These projects were undertaken by 18 different firms located in the U.K. (throughout this report when we speak of U.K. firms we are referring to their location rather than their ownership.). A further six interviews, relating to five of the projects were held with firms that had been engaged as subcontractors.

2.7 The questions concentrated on identifying and, where possible quantifying, evidence on the following aspects of benefits resulting from the financial support provided[6]:

- benefits for the lead business itself in terms of additional sales to customers in space and non-space markets and gains to the entities' competitiveness
- benefits for subcontractors employed on the project

[6] Many of these benefits will be appropriated directly by the originating firm itself. However, others may well diffuse along the supply chain and into the wider economy. For these, the likelihood is that there will be some benefits that the originating firm will not be able to appropriate in full. For instance if a licence is granted for the use of protected IP generated through the project, it may be that the licensee gains greater benefit than the amount they have to pay to the originating firm.

- commercial use of the project results by others that did not participate in the project.

2.8 As annex one sets out, the first aim of the interviews was to identify any transfers of knowledge or technologies between beneficiaries of DTI support and other firms. To achieve this we had to extend the concept of spillovers to include benefits which beneficiary firms may have been able to appropriate. One implication of this approach is that a simple count of incidences where transferred knowledge has been transferred is likely to exaggerate the case for the programmes, if they were justified on strict market failure grounds.

2.9 Impacts were reviewed against a set of descriptive variables and the key results are presented in answering question 6 where do DTI funded programmes offer the greatest potential for generating additional economic benefit? That same discussion is informed by four interviews with firms that were thought to have the capability to participate in BNSC or ESA business support related civil space programmes but have not done so to date.

2.10 There was a concern, expressed both by BNSC and in our discussions with a group of industry leaders, that the distribution of benefits to firms and, in particular, the distribution of benefits that cannot be captured by the firm itself, attributable to the 5 programmes may be highly skewed. To correct for this possibility, interviews were held with 8 firms and one research laboratory that together received around 60% of the funds allocated by the five programmes. These interviews asked more generally about the commercialisation of knowledge developed for the civil space sector, including: commercialisation by the firm itself and by new start companies based on civil space expertise but principally serving non-space markets; and the use of space outputs by other businesses outside the civil space sector.

Methodology for the downstream benefits

2.11 The exploration of 'downstream' benefits from 'upstream' efforts to create new space technologies and products has to be couched in more general terms. It is not possible to discuss these downstream benefits in relation to the five business support programmes on which the upstream interviews focused[7]. Rather the downstream benefits, especially the social benefits/externalities that firms may not be able to internalise, may provide a general justification for the UK taking seriously the opportunities offered by space technologies. The relative advantages of developing these in the UK, as against buying them from elsewhere, is of course the key qualifying question since many of these services may well have been provided in the absence of UK space funding.

[7] In some cases the projects we reviewed were too recent for any downstream impacts to have accrued (lead times can be very long). More generally, the major downstream impacts are typically caused by the interaction of several innovations that together create a platform or infrastructure for wider use. Past experience suggest that not all these innovations will arise from space related activities. Disaggregation of causality may be possible but only through highly intensive case study methodologies.

2.12 Necessarily, most of the evidence on downstream benefits came from the analysis of existing academic, market and evaluation material. It was, however, supplemented by some 20 contextual interviews with:

- experts on spillovers and downstream impacts (including US space bodies)
- firms active in the three main areas of downstream applications
  - communications
  - navigation
  - earth observation and remote sensing.

2.13 The selection of individuals to interview was made with advice and assistance from the BNSC.

3 What have been the past trends in space technology and user markets and how are these likely to develop in future?

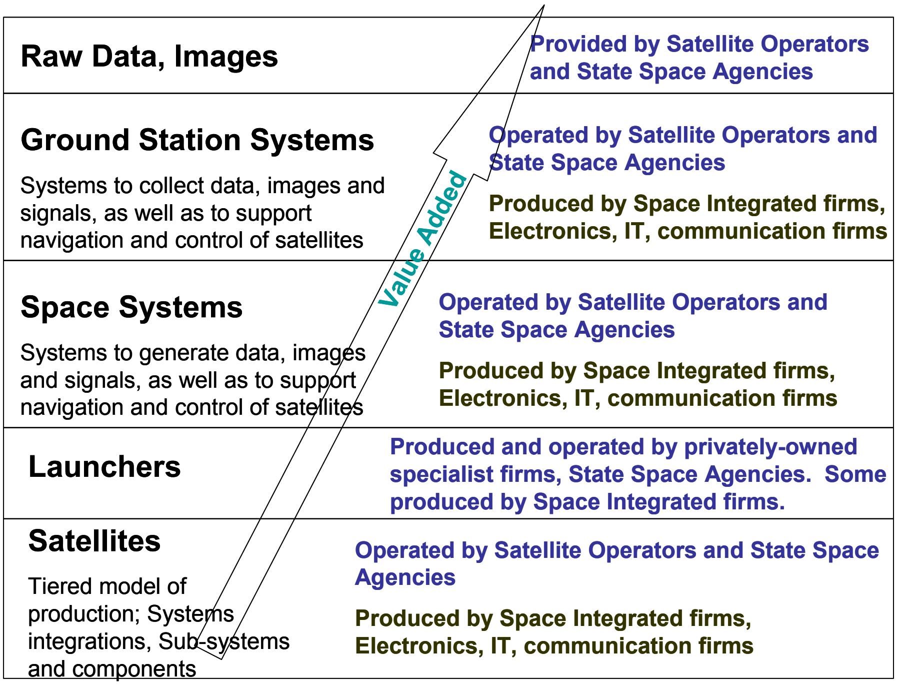
3.1 This question is explored at some length in module 2 of the technical report *Space Industry Context*. Much of this draws on published material but we took the opportunity to seek the views of firms during our interviews with them and it is this evidence that is summarised here. It is important to recognise that the technology and market trends reported by the companies interviewed are shaped by the current business activities and strategic focus of the companies themselves. Despite this qualification, policy makers need to understand companies' perceptions as it is these that will determine their responses to any incentive framework.

Global factors

3.2 Received wisdom is that civil space activity occurs in cycles. Of course, these cycles have become more complex as both public and private customers for civil space assets undertake investment separately and without co-ordination. Within the public sector, the peace dividend from the end of the Cold War resulted in a significant decline in military spending until recently. Civil space research has also declined substantially in the US (particularly since the heyday of NASA in the 1960s) and Europe. To add to the weakness of public sector demand, the demand from the private sector has collapsed since the late-1990s. Given these asynchronous demand cycles and the steep investment costs of asset development and launch, the resulting consolidation in market leaders is understandable and perhaps unavoidable. There is a view that further consolidation is still likely. As a result Governments are likely to come under pressure to increase public funding if they wish to retain indigenous space capabilities at current levels.

3.3 Given the high concentration in these Civil Space Stack industries[8] (particularly those of satellites and launchers), there is speculation over what role the UK industry will play without a leading asset manufacturer (satellite and/or launcher) in the field. Certainly, the UK maintains a good position in small satellite production, but the growth evidenced in this niche market has attracted interest from the largest satellite producers. It may be difficult for the UK to maintain leadership in this segment unless the producers' business models are focused firmly on downstream application needs.

[8] See annex 2 for further information on the markets related to civil space activity



3.4 An important developing trend has been for customers to purchase services rather than space hardware and systems. Service providers have generally been more successful at generating profits. Some system providers are seeking to move into this more profitable area through PPP arrangements and other service contracts which may allow them to sell surplus capacity onto the open market. In effect upstream companies are following similar trends to other parts of manufacturing, such as aerospace more generally, where manufacturers are increasingly becoming service providers[9].

3.5 Although the focus of our project is ***civil*** space activity, we must recognise that this is an artificial split for many space asset producers. Moreover, the dual-nature of many space assets necessarily affects the ability to trade these outside national boundaries. Following the 9-11 disaster, the US markets have closed considerably, limiting purchases from non-US (based) companies as well as sales to buyers in other countries. Allied countries have some special concessions in this regime, but not many. Ironically, technology transfer and discussion between the UK and the US would seem to be comparatively easier in the military sphere than the commercial one.

3.6 The political imperative for the US is seen by many participants in the sector and its observers to be to maintain all necessary space capabilities within US borders and to treat these as national advantages. This hardening of stance consists of a ramping up of existing controls that are also a feature in many countries worldwide. Because of the dual-use nature of many

[9] For example, car manufacturers sell insurance, leasing and maintenance services; aircraft manufacturers sell or ease hours of flight.

assets in space (launchers, satellites, control and imaging systems), many of these items are strictly controlled in terms of export licenses depending upon the country of origin (and the import restrictions and requirements of destination countries). This implies that companies that wish to remain at the vanguard of the civil space industry will seek strategic placement of their subsidiaries globally. The US – by far the largest investor in space technologies – is likely to remain the most attractive destination for subsidiaries for the foreseeable future, especially since defence expenditures have increased substantially post 9/11. US owned firms are likely to be much better placed during further rounds of industrial consolidation.

Views of UK space companies: technology

3.7 Recent trends identified by companies were:

satellites

- smaller, lighter satellites with lower weight, capital cost and launch cost (providing 80% of the functionality at 20% of the cost)
- use of ion engines for satellite positioning contributing to weight reduction and potential longer future satellite life
- several satellites have gone on working for considerably longer than expected – with costs advantages for user but leading to lower than expected replacement demands

space systems

- development of digital communications satellites offering greater capacity
- developments in synthetic aperture radar (SAR) that allow reduced antenna size
- on board processing for EO data leading to greater effectiveness
- novel technologies for more intelligent instruments that are lighter and smaller

ground station systems

- improved ground control and positioning software
- web-based control of satellites with TCP/IP protocols replacing specialised software and enabling more scientists and engineers to control satellites and experiments
- grid computing makes massive EO datasets more accessible and manageable

science applications

- advanced use of robots permits greater mission autonomy and more effective unmanned space exploration.

3.8 Two key current drivers in technology development were identified by firms: cost-efficiency and quality (largely within existing architectures). Many of the anticipated developments in technology relate to advances in space system components to use the fuller spectrum of RF signals as well as enhanced control and adjustment. Small satellite development is also anticipated to continue, reflecting a greater flexibility for users in terms of cost and satellite placement. Greater bandwidth options are also expected to result in new satellite designs.

Views of UK space companies: markets

3.9 Recent trends identified by companies were:

Communications

- dramatic fall in telecoms prices because of overcapacity in terrestrial fibre networks
- reduced demand for large satellites from telecoms sector, capacity requirements now driven by moving image and data rather than by voice
- growth in niche markets for broadband links (e.g. communication with shipping)
- greater bandwidth from Inmarsat creating new scope for communication with aircraft
- UK political support for extending broadband interactive networks into remote areas

EO

- growing awareness of the need to monitor environmental changes
- government awareness of EO potential e.g. for compliance applications

navigation

- political support for securing European independence from US systems (Galileo)

satellites

- demand from various smaller countries for direct ownership
- US military interest in multi-channel airborne satellite communications systems

broad contextual factors

- strength of sterling
- large French and German national space programmes reduce the competitive position of UK firms

3.10 Despite the evidence and views we gathered from our reviews and consultations that enabled the above trends to be identified, there was an overall sense of uncertainty about future market trends and therefore a concern that decisions are likely to involve a high degree of risk taking. Companies commented less on their own markets than on the downstream application markets, notably communications and earth observation. Overall, UK space companies anticipate growth in downstream application markets and therefore growth in demand for civil space assets, such as satellites and enhanced satellite systems. Moreover, the companies are clear that government at the European level primarily needs to play a role to counterbalance the US influence in civil space activity.

3.11 Nevertheless, these UK companies anticipate further rationalisation amongst satellite manufacturers and look hopefully to Galileo (see Appendix 4 for our commentary on these hopes) and growth in the demand for small satellites to prove profitable for the UK sector. The companies recognise the challenge posed by the ‘commodity trap’ when competition is determined by price level. The need to build added value through bundled products and services is a trend that is also found in many other sectors of the UK economy, namely high value capital goods industries such as aircraft engines and defence training simulators. In a number of market segments, commercial success is likely to require greater integration between firms in upstream and downstream segments.

4 Where are the UK's relative strengths and weaknesses in the exploitation of Space?

4.1 The views reported below come in the main part from discussions with the eight companies and one research laboratory that together received 60% of the funds from the five business support programmes (the 'main beneficiaries'). It was generally recognised that the UK does not participate at all in certain areas of space such as manned space systems or launchers and that this tended to lead to strengths in areas where the UK does participate and weaknesses in others.

4.2 The paragraphs that follow give this feedback and may be helpful to the on-going dialogue between firms in the sector and government. Contextual information from published research is provided in annex 2 where a short discussion comments on some key differences.

Areas of the civil space sector where firms we interviewed considered the UK to be particularly strong

4.3 Following the structure shown for the civil space stack shown in figure 1, firms consider the UK to be strong in:

satellites and payloads

- specialist payloads used on large satellites where the UK retains world class expertise
- beam forming digital antenna where the UK has a world lead based on advanced digital processing leading to major gains in flexibility
- small satellites where Surrey Satellites has established a world lead in developing both the technology and the market for constellations of small satellites, and Qinetiq among others is also strong
- ion engines where UK companies have demonstrated the effectiveness and reliability of ion engines on scientific missions and their potential for extending the expected operational lives of commercial satellites
- Synthetic Aperture Radar and on-board analysis
- Lithium Ion Space batteries
- space science including specialist instruments and high reliability systems requiring autonomous operation
- scientific missions where UK companies design and manufacture extremely high reliability systems that are required to work after extensive journeys through space and with high precision innovative instrument packages. Recent examples include the Mars Express and Beagle 2

- use of standard components where standard chip-sets are being used in place of high cost application specific integrated circuits
- reducing the cost of satellite cabling through the use of multiplexed systems and low powered radio transmission

space systems

- on board and ground segment software eg mission and satellite operations control
- space environment monitoring to understand the trajectories of space debris and space particles and allow satellites to take evasive action to protect themselves
- simulation tools including control of satellites and how to assign capacity on non-linear transponders

ground station systems

- airborne ground segment where the UK has a world lead in systems for providing in flight telecommunications and is in the forefront of the development of broad-band access for passengers
- ground segment software, in particular, the operational control systems for satellite control
- use of airborne ground segment for navigation where UK companies are at the forefront of developments in areas such as aircraft broad band multi -media systems to enable improved in flight data and communications
- control of large telescopes where software developed for space applications is used to control the pointing of large telescopes world-wide

downstream applications

- EO applications where the UK has developed important applications for sectors such as oil and and in managing networks for the distribution of EO data
- software and application specific services
- operation of communications satellites with major players such as Inmarsat located in London
- the development of services to take advantage of the capabilities of the Galileo navigation system
- value added services including satellite operation and direct to home broadcasting companies.

Areas of the civil space sector where firms we interviewed considered the UK to be particularly weak

4.4 Firms consider the U.K. to be weak in:

prime contractors

- major mission prime contractors
- large satellites buses because of worldwide over-capacity resulting from the recent fall in demand for large satellite systems and the commoditisation of this market. The recent withdrawal of BAe Systems from Astrium is also thought by some to be symptomatic of this weakness

launchers

- launchers where there is no significant UK player (as an outcome of deliberate policy decisions)

manned space

- manned space and support systems for hostile environments

navigation hardware based on GPS

- lacking an indigenous navigation programme. The UK (and Europe) has been at a disadvantage in the development of hardware and value added systems for navigation because the US Department of Defense system (GPS) has provided US companies with a head start in developments and this has tended to disadvantage non-domestic suppliers
- in-car navigation systems and location-based services where the Japanese are particularly strong (although France also claims strength here)

organisational and institutional

- some UK programmes being spread too thinly and with too little time permitted to develop effective proposals.

5 How well placed are U.K. based firms or institutions to exploit these trends?

5.1 In bringing together views on market trends and on U.K. strengths and weaknesses to answer this question, there is a need to intrude the team's own views. These are, in some respects, less positive than those of the firms we interviewed.

5.2 Within the Civil Space Stack, the UK's greatest activity is now clustered largely in the space and ground station systems, with some activity in large satellite buses. As discussed earlier, there is a growing UK capability in small satellite production in terms of Surrey Satellites and Qinetiq. However, this is becoming a more contested market, as the largest satellite producers (such as EADS/Astrium, Lockheed Martin and Boeing) are moving in. The greatest threat probably comes from EADS/Astrium, because unlike its US competitors, European defence spending has not increased. However, this is not to say that there are no current orders for large satellites. Previously delayed orders by operators are coming back online.

5.3 The key issue for suppliers of space and ground station systems is the strength of their linkages to the prime contractors and the final users, often the principal funding bodies (both space agencies and operators). Britain's strengths in its electronic and IT industries are reflected in the comparative strengths of British suppliers of space and ground station systems. However, these firms have no national advantage in terms of final users and contractors. The leading prime contractors are no longer headquartered in the UK. Of the leading satellite operators, only INMARSAT is based in the UK. The bulk of public sector spending on such assets is not strictly controlled in the UK. Therefore strategies to support these firms in the future must address how to effectively work these 'weak ties' through familiarity and technological performance.

5.4 Without a doubt, downstream market applications such as satellite-supported communications have grown to be significant threads of the economic fabric, and they represent important shares of GDP across the OECD nations. It is worth noting that the UK has two leading firms in these highly-contested, price-sensitive markets (Vodafone and BSkyB).

5.5 This is not the case in the growing markets for GPS receivers and services, where none of the leading firms is headquartered (and some do not even have sales offices) in the UK. It is widely thought that North American firms are dominant in these markets mainly because the US Department of Defence fully funded the GPS infrastructure. Galileo may alter the balance across the globe, although, by design and negotiation, Galileo and GPS are seeking to become complementary in coverage and services. Research is being undertaken to enable the eventual implementation of the Galileo system that may provide opportunities for UK companies to develop new hardware and services in the developing field of navigation. However, it must be recognised that the existing navigation services firms have substantial first mover advantages in technological development and the distribution aspects of GPS services, particularly in the consumer market. Moreover, these firms are already actively designing and developing receivers for Galileo signal services, and they are investing heavily to position themselves for new opportunities provided by Galileo and the GPS-3 upgrade (in 2002 Trimble alone spent $61.2 million - or 13.5% of its turnover - on R&D). Industry pundits expect that users may ultimately use receivers that are capable of accessing both GPS and Galileo systems, and therefore they may benefit from using a wider mix of satellites for a better quality and more robust location signal.

5.6 The case for remote sensing and Earth Observation is perhaps the most complicated, insofar as there is not much of a private sector market to speak of. Apart from the oil and gas industry (and intermittent take-up of services by other sector, such as was the case for telecommunications infrastructure), remote sensing and Earth Observation are only used in any significant scale for weather forecasting at present, although there are expectations of growing markets in the public sector eg for compliance monitoring. In the UK, the Met Office appears to have developed an important business selling its weather forecasting services on to private weather companies and the like. Moreover, the UK is home to two of the leading remote sensing service providers to the oil and gas industry (Nigel Press Associates and Infoterra). In the case of Infoterra ownership was recently transferred to Astrium and the extent to which it will remain a UK-based company is not clear.

5.7 Of equal importance, recent studies conducted by ESA have revealed that the UK has relatively few remote sensing and EO companies, as most are based in France. However, this is not to say that the UK is missing out at present on a developed and profitable market; this market is very thin and future trends in services appear better suited to public service requirements and a few specific commercial needs (e.g. risk profiling for insurance companies). ESA’s current view to make all data and images free to all companies also threatens to destabilise this emergent industry further.

6 What market failures affect different programmes, technology segments or markets (including an assessment of relative severity)?

6.1 Market failures provide one of the main planks for a Government decision to intervene. Typically the outcome of a market failure will be levels of investment that are below what is justified in terms of overall benefits to the economy and society. Intervention seeks to incentivise firms to increase their investments and thereby reach nearer to the overall optimum levels (see Annex 1for a fuller consideration of this topic).

6.2 The review of existing academic, market and evaluation material, did not cast light on different levels of severity in market failure in technology segments or markets. We would, however, offer three tentative comments in this respect:

- it is worth recognising that the existing platforms currently supporting the satellite based communications markets, the GPS markets and the remote sensing markets were largely funded and supported for national security reasons rather than for economic ones. Issues of market failure did not figure in those decisions; the objective was to get the best quality platform in space and to develop secure access (frequently using home grown companies) to industrial technologies and capabilities pertinent to these activities

- in the academic literature the market failure argument has only been raised in the circumstances of weather and climate information, notably in the report by Williamson, Hertzfeld and Cordes (2002) on *the socio-economic value of improved weather and climate information.* These authors focused on the problems of co-ordination across multiple actors and the underlying complexity of the science. However, this report (prepared for NASA) refrained from discussing whether private sector trade will develop to fulfil these needs

- the Evaluation of Funding for UK Civil Space activity (2001) noted that *"while the concept of market failure has been at the heart of the DTI position throughout the period, the interpretation of what this means for DTI strategy has evolved over time. In the period since 1988, DTI has moved from general bulwark of UK space funding (access to strategic infrastructure) to active policy customer seeking to facilitate the active participation of the UK space industry in those applications with the greatest commercial potential." (Technopolis p 34).*

6.3 At a general level, a number of factors make the space sector distinctive with relation to market imperfections:

- on the demand side most segments are dominated by a few major buyers – be they government, international agencies, or large firms
- a number of applications markets are still at a quite early stage of evolution in which latent demand will only become tangible when the necessary infrastructure is in place (which in part explains the pivotal role of government)
- a number of the major applications of space-facilitated technologies are justified in terms of the social or environmental benefits rather than direct economic impacts. The pace of take up will be determined by the changing complexion of political values and priorities
- there are important interfaces between civil space and national defence/security activities. This makes for impediments to information flows and an enhanced risk of interference by government for reasons that are sometimes erratic and always hard to predict when assessing risk
- the supply side has a small number of large firms that are closely networked on issues such as influencing government policy. Some SMEs believe that it is difficult to break into that coterie.

6.4 Specifically in relation to the five programmes that are the focus for this report, the sheer dominance of a few firms is striking:

- for BNSC Satcomms, two firms have received 63% of the funding
- for BNSC EO, one firm has received 40% of the funding
- for BNSC ATS, one firm has received 65% of the funding
- for ESA ARTES 3 & 4, two firms have received 49% of the funding
- for ESA GSTP, one firm has received 48% of the funding
- for the 5 programmes totalled together, one firm has received 34% of the funding through 51 of the total 164 contracts (31%).

6.5 High levels of additionality are usually seen as a sign that market failures exist and that public subsidy to mitigate the effects is justified. If additionality is low then one can infer that firms use public funds to substitute for private financing with the benefits accruing to owners and shareholders through higher profits or dividends. High levels of additionality can also occur if public funding seeks to support activities which the market would not otherwise provide, for perfectly valid reasons, on the same scale. Such an instance occurs if consumers do not want to acquire the good or service on offer at the price sought. In this case, through the tax system, the Government transfers resources to subsidise goods or services that it believes has merit.

6.6 Project executives were questioned about additionality, which indicates their overall judgement of market imperfections, and they had a considerable commonality in their views. When asked what would have happened to the project in the absence of the BNSC / ESA grant, the responses were that:

- in 15 of the 22 projects a lack of funding would have meant no participation by the unit in the project – this included six projects undertaken by the three large firms
- three projects would have still continued but two would have been with a lower scale of involvement in the project and a further one would have been of a lower quality
- for the remaining four projects the units stated that their participation would have been negotiated over a longer period of time: one commented that it would have taken two years to make the same level of progress without the grant and in the meantime they would have missed out on a number of business opportunities; a second commented that the grant allowed the project to move forward at a much faster rate and not in piecemeal fashion
- for eleven projects it was claimed that without the grant they would have failed to win contract business that had been achieved.

6.7 The sample size did not allow us to distinguish variances in additionality levels between the five programmes. Nor was any other evidence obtained by which differences in the severity of market failure could be distinguished between programmes.

7 To what extent does the UK-based space industry generate benefits to sectors that trade technologies with the space industry?

7.1 In answering this question we need to consider a broad application of the 'spillover' concept to cover the knowledge and technologies that having been generated in the course of civil space activities can be applied (i.e. transferred) to other applications, regardless of whether the innovating firm is able to appropriate the benefits of such a transfer. There are lengthy reports with examples of such spillovers, published by both ESA and NASA. We have also gathered the views of the main UK Civil Space manufacturers and BNSC staff. We can summarise potential spillovers into four main categories: dual-use technologies, safety critical industries, multi-purpose applications and spin-offs from civil space activity.

Dual-use technologies

7.2 Many supporting technologies and capabilities related to the space stack have both civilian and military applications. One set of examples cover the military use of space technologies in:

- controlling constellations of UAVs
- the use of satellite downlinks technology in aircraft
- the use of small radars in UAVs (where BNSC investment played an important role)
- the use of space derived simulation tools to optimise battlefield systems.

7.3 There is widespread application of civil satellite technologies for military applications in both communications and EO. Many military applications are highly dependent on space technologies e.g. GPS and EO data being used for military reconnaissance, planning and targeting. Another example, given by interviewees, is the use of space batteries in military mobile communications systems.

Safety Critical industries

7.4 Space asset production also trades technologies and capabilities frequently with other 'safety-critical' industries. By safety-critical, we refer to those industries for which systems, component or parts failure carries very high costs; prompting a strategy to reduce the likelihood of failure to as low as possible a level. Safety-critical industries include aeronautics, water distribution, electricity and gas distribution, railways, medical care and the like.

7.5 Software control systems play an important part of these industries, and this is a clear area of trade in technologies and skills with civil space. The software used for satellite control is also used in other areas. For example, the software used to control constellations of satellites is also used to control water distribution and gas distribution. The use of control software developed for financial services has also facilitated the development of complex space project management systems using web based portals to allow consortium members in different locations, companies and countries to communicate affectively. Control software has subsequently transferred from the space sector to the military aerospace sector.

7.6 There are also examples of spillovers which are not software-based amongst safety-critical industries. Within the aeronautics industry, both aeroplane and aero-engine manufacturers maintain major exchanges of technology with the space sector. In some cases, companies are involved in both sectors, e.g. EADS which owns Astrium and where space technologies are seen as being of strategic importance. The industry is frequently described as “aerospace” for these precise linkages.

Multipurpose applications

7.7 Spillovers are most evident when the transfer involves a multipurpose capability or technology. Examples include the development of capabilities in the expert use of satellite communications for connectivity and the development of simulation methods (which involve proprietary software). Clearly, better communications and training technologies have scope across many industries. In our interviews, the use of satellite communications was deployed in a project for a gas company, introducing staff from the supplier’s space department into the project as required.

7.8 Technology also transfers through components within the space systems. There is much scope for technology transfer in the field of electronics, where space communications technologies are being used for HF radio devices. There is a regular interaction between space and electronics in areas such as the use of higher frequencies in space for communications satellites and the specialised transistor technology required to meet the necessary power outputs at these frequencies. There is also scope for technology transfer in instrumentation, where novel space instruments such as CCDs may find use in a wide range of other devices, such as lower power X-ray devices for dentists. Interviewees noted that there is medical equipment which may make use of particular techniques, such as specialised polishing to develop improved implants or where tele-medicine opportunities have been facilitated by broadband space based communications.

7.9 The interchange of ideas and techniques has been long-standing between space and the telecommunications and wider communications industry. Moreover, newer space-based techniques such as advanced modelling of stress in systems are being used to optimise 3G mobile phone architectures and to model the functioning of 'breathable' cell structures under different conditions of stress.

7.10 More general transfer occurs with respect to techniques and materials for space that are used in other sectors. Such examples include new insulation materials, high precision / high reliability components, light weight components, shape memory alloys and the like. Undoubtedly, techniques and expertise developed on civil space projects by research staff can be redeployed in a number of fields, considering the wide number of scientific disciplines of the staff involved in publicly-funded civil space projects.

7.11 Not all capabilities and technologies migrate from civil space to other sectors. In fact, there are many examples where capabilities are brought to space projects from other fields. TEFLON is probably the best known case study of this sort, whereby TEFLON was a chemical developed in 1938 by Roy J Plunkett at Du Pont that later found an additional (and much publicised use) in civil space projects. In section 8 we highlight the likelihood of increasing opportunities for technology spin in from other sectors.

Spin outs

7.12 In some cases, a spillover product or capability becomes the basis for a spin-out company. This has been the case for some of the companies interviewed for downstream market applications. Companies like Nigel Press Associates are essentially actively developing the outputs of civil space research for a range of commercial markets.

Survey results

7.13 The results from our survey confirm, albeit to only a limited extent these more general observations.

links with military space work

7.14 As well as their civil space work, 12 of the 18 firms covered by the survey were also involved in military space work but the importance of military projects was quite small for most; ranging between 1% and 25% of turnover. All five main beneficiaries (firms receiving high levels of support from the programmes) were involved in military work, but three of the small firms also covered military as well as civil space work

7.15 For the 12 firms that undertook military as well as civil space work, the civil work had preceded military in 83% (10) cases and 11 firms reported that civil was more important in technical terms. The relative contribution to the firms' profit margin was slightly more evenly split; seven firms felt civil was more important, three said military and two stated the two were of equal importance to their business.

7.16 Firms were asked about the relationship between their civil and military functions, and their responses are shown in Table 2 below. To summarise, the vast majority answered either ‘nearly always’ or ‘usually’ in terms of: synergies between military and civil space businesses; and the sharing of technology, processes, expertise and business functions.

Table 2: Firms’ rating of the relationship between military and civil space work in their business

	Nearly Always	Usually	Quite Often	Sometimes	Hardly ever	Don’t Know
. . . there are opportunities for synergies between our military and civil space businesses	6	3	2	1	0	0
. . . our military and civil space programmes share technology	6	5	1	0	0	0
. . . our military and civil space programmes share processes	7	4	1	0	0	0
. . . our military and civil space programmes share expertise	7	4	1	0	0	0
. . . our military and civil space programmes share business functions such as marketing	7	2	2	0	1	0

Applications of project results outside the space sector

7.17 In 16 projects the results of the project have been used commercially by the business (probably thereby appropriating most of the benefits) – this included nine multi-sector firms and five space only firms (two space only units were involved in more than one projects so for seven of the projects the unit was focused on space only markets). The results from six projects (equally split between multi-sector and space only firms) have produced benefits for non-space work including:

- in three projects the products, services and expertise developed from the project has enabled the unit to enter a totally new market unrelated to space
- one of these three projects has resulted in sales to existing non-space customers (not an additional project)
- for two projects the results have been modified and embodied in products, services or expertise of non-space offerings (one additional project)
- four projects have led to improved techniques or processes which were used in non-space parts of the business (one additional project)

- five projects resulted in the development of new skills which were applied to the non-space part of the business (one additional project)

7.18 Sales of space related services to non-space customers this have included:

- the transfer of space related expertise and techniques to the pharmaceutical industry and also to techniques for unmanned air and water exploration
- general improvements in capabilities in the areas of CAD, management and analysis.

7.19 In the two cases where the results have been modified and embodied in the products, services or expertise of other non-space product offerings this led to:

- one of these firms making a subsequent investment of around £1million in order to launch satellite based TV services and internet access via satellite
- a second firm, through minimal investment, pursuing opportunities in the multi-media education sector in Eastern Europe and also in the defence sector.

8 Where do DTI funded programmes offer the greatest potential for generating additional economic benefits?

8.1 Our evidence in answering this question derives primarily from the survey of firms and here there is a clear limitation as a result of sample size. Despite the rigour with which the sample was drawn the 22 project interviews do not permit robust generalisations – though given the highly skewed distribution of fund allocations, and confirmatory evidence from interviews with main beneficiaries, we believe that the findings offer worthwhile insights for policy review.

8.2 There is a crucial phrase *additional economic benefits* within the question which, we suggest, may be viewed differently depending on the viewpoint taken. Some of these benefits will have been appropriated by the firms themselves (if the justification for space funding were strictly on grounds of market failure then we would only consider the benefits firms cannot appropriate). There were many positive outcomes from the supported projects (and as explained in paragraph 6.3 there was a high degree of additionality) but there is some rather disappointing evidence too.

Positive findings

8.3 Starting with the positive findings specifically related to the projects, they were, very largely, successful in terms of their objectives. Twenty-one of the projects met all of their technical objectives with the one other project stating that it was too early to judge. Furthermore 20 projects stated that participation had met their strategic objectives for involvement and 17 projects had met the units' commercial objectives – for four it was too early to tell. One project had not met that unit's commercial objectives principally because the potential customer for the product being progressed through the project is no longer interested.

8.4 Moreover, tangible outcomes have been achieved, despite a number of the projects still being fairly early on in their planned duration. Seven of the 17 BNSC projects claimed that the project involvement was important in winning subsequent contracts from ESA. The total value of these projects was approximately £32 million. In a further six of the BNSC projects the unit has not yet directly won any ESA contracts but the project has been used as an important piece of evidence to demonstrate their space experience and heritage when bidding for future work.

8.5 In addition to these contracts, seven firms identified sales of products or services arising from commercial use of the outputs from the project as shown in the table below.

Table 4: Sales of products/services from the sample of 22 projects						
Firm	Sales of products services (£)	Time profile of sales	Size of own investment by firm to get sales	Value added	Proportion of goods and services that are UK sourced	Uniqueness of product or service
1	First 1,000 units of the product ordered					
2	£5m	3 year operational agreements	£1m	30%	5%	Unique when started – now other competitors but are the market leader
3	£140k	See the benefits over the next 2-4 years	£120k-£180k	20%	100%	Unique
4	£450m	4 years – options remain for additional sales	£30m	33%	2%[10]	Unique – only one other supplier capable of doing comparable work
5	£1m					
6	£7.5m	Between 1999-2003 – number of orders has been steadily rising[11]	£450k plus time and effort required to raise profile of the business	Between 65-75%	95%	Unique when started – one other European competitor but they do not have the range of products. A couple of US suppliers but they have had little success
7	£30k	Summer 2003 –contract over a period of 3months	£2.4m[12]	Very difficult to judge	Don't know but likely to be less than 5%	Only supplier that can provide this service, which is also not a competitor to the manufacturer that the firm has won the contract from

8.6 There were also positive findings from the 29 U.K. based subcontractors working on the 15 projects. Responses were obtained from 14 projects (one subcontract had only started quite recently).

[10] This is a best judgement estimate of the contract value for first tier suppliers only.

[11] Sales are expected to continue with a number of new contracts to be signed shortly.

[12] This mainly includes multiple investments from the foreign parent company which has resulted in the development of a substantial IP portfolio. This investment alongside the BNSC grant has led to the sales.

Collaboration between the lead firm and the sub-contractors (as seen by the lead firm)		
	Yes	No
. . . my firm gained new skills and/or technologies from the sub-contractors	8	6
. . . my firm gained new staff from the sub-contractors	0	14
. . . the sub-contractors gained new skills and/or technologies from my firm (or other sub-contractors)	10	4
. . . the sub-contractors gained new staff from my firm (or other sub-contractors)	4	10
. . . no change – there was no transfer of technology and skills across the project companies	2	12

8.7 Of the 10 projects in which the sub-contractors gained new skills and/or technologies, nine were based on collaborative interaction with the sub-contractors working alongside as partners in the design and management of the project and two of these nine projects involved the co-location of staff.

8.8 For the two projects in which no transfer of skills and/or technology took place the sub-contracting relationships were purely commercial with the subcontractor responding to set specifications rather than working collaboratively.

8.9 The units were also asked about any other benefits from project collaboration – they highlighted such examples as:

- an improved working relationship and greater knowledge of each other's skills and business, which led to further collaboration and the forming of strategic relationships
- a better understanding of the academic community and its requirements
- exposure for SMEs to the technical depth and contacts of large space firms
- a stronger commercial presence in a competitive global market
- research into new technology areas that the firm would have been unable to do alone.

8.10 In considering the importance of the impacts described above it is relevant to note that of the 11 subcontractors that had benefited from new skills and/or technologies, seven were multi-sector firms and four were space only firms.

8.11 We also interviewed six subcontractors directly (the hope had been to cover more but this proved infeasible). All six saw civil space work as being beneficial to their staff. Four firms feature civil space programmes as a way of recruiting staff and five felt that there is a certain kudos attached to staff who have participated in civil space programmes. The specific learning benefits mentioned by five of the firms included:

- the discipline of undertaking ESA work – by ESA dictating the project reporting and timescales this forces the firm to carry out R&D in a particular, organised way
- the development of advanced skills and techniques
- the involvement of staff in a number of areas of product development such as integration and testing.

8.12 All six firms said that the sub-contract in which they participated had met all the technical objectives – five also stated that the sub-contract had met both the firms' commercial and strategic objectives for participation. For three firms the sub-contract was important in winning subsequent contracts/sub-contracts; the other three firms are using this project experience to try and win future space work.

8.13 In five firms the results of the sub-contract have been used commercially by the business and three firms hope that the products, services and expertise developed from the sub-contract will enable them to enter a totally new market unrelated to space. These applications include: working with an automotive manufacturer and also an aerospace firm; developing products for the terrestrial TV market; providing a generic skill base which can be used in a number of applications.

8.14 Two of the six sub-contractors were able to quantify sales of products/services to other customers arising from the subcontract. One firm has sold equipment to the value of £400,000 and a second firm has achieved sales of £20,000 to date with the potential for much more. A third firm said that through being a 'service' based company the concepts used in the sub-contract are broadly applicable to other work that it undertakes.

8.15 With regard to project collaboration, three of the sub-contractors said that they gained new skills and/or technologies from the lead firm, whereas five firms felt that the lead firm gained new skills and/or technologies from them.

benefits from lead firm's overall involvements with civil space work

8.16 In addition to answering question about the specific benefits they received from the projects, the units interviewed were asked to comment on their general experience of grant funded civil space work. Again the findings point, encouragingly, towards enhanced innovation.

.Participation in civil space work for which you have received a grant contribution towards the total cost has. . .

	Agree	Disagree	Don't Know
. . . met your strategic objectives for involvement	17	1	0
. . . strengthened your established lead over competition	16	2	0
. . . enabled you to catch up with the competition	8	10	0
. . . proved an unfortunate distraction from your core markets	0	18	0
. . . facilitated your entry into new product/service markets	13	5	0
. . . developed or retained key skills in your business	18	0	0
. . . kept you alert to technological developments	16	0	2

Table 7: Specifically because of *grant funded* civil space projects, we…..

	Yes	No	Too Early
. . . started new R&D activities that otherwise would not have been initiated	15	3	0
. . . developed new products/services that otherwise would have remained dormant	15	3	0
. . . increased our stock of R&D personnel to a scale that otherwise was not justified	9	9	0
. . . had to downscale or cancel other planned R&D or projects	0	18	0
. . . had to reallocate resources from other planned activities	3	15	0
. . . increased our market share at the expense of other UK businesses	4	10	4
. . . increased market share at the expense of foreign companies	10	4	4

8.17 Finally firms were asked to rate the benefits derived from their overall participation in civil space work, whether or not grant funded and to comment on their motivations for being involved. Again the responses were positive, most notably in respect of:

- development of new products
- development of new or better skills and working practices
- development of alliances and long term collaborations.

How would you rate the contribution of your participation in civil space work to…	Very high	High	Average	Low	Very low	Don't know
. . . development of new products	7	7	2	1	1	0
. . . development of new manufacturing processes	3	3	4	3	4	1
. . . development of new markets not related to the civil space sector	2	5	4	3	4	0
. . . development of new or better skills and working practices in the firm	5	8	3	1	0	1
. . . quality control and enhancement	2	6	3	4	3	0
. . . improved efficiency (less waste, better stock control etc.)	1	3	5	3	3	3
. . . development of alliances and long-term collaborations	5	10	1	1	1	0
. . . enhanced identification and adoption of technologies from other firms or industries	3	2	8	3	1	1

To what extent are the following factors important in your choosing to be involved in the civil space business	Very high	High	Average	Low	Very low
. . . a profitable line of business – with good margins	4	7	5	1	1
. . . important for developing expertise that is applied elsewhere in the business	3	10	3	2	0
. . . important for developing research that is applied elsewhere in the business	2	11	1	2	2
. . . important for developing technology that is applied elsewhere in the business	2	11	1	3	1
. . . important for developing relationships that is applied elsewhere in the business	3	9	4	2	0
. . . important for your reputation with non-space UK customers	6	5	4	1	2
. . . important for your reputation with non-space customers overseas	5	6	4	1	2
. . . it's a natural market because of our involvement with military space business	1	5	2	3	1
. . . perceived future commercial potential	5	9	4	0	0

Disappointments

8.18 The project interviews were very disappointing in terms of formal transfer of intellectual property. There were no royalty flows or even licences identified, despite the fact that for 21 of the 22 projects the intellectual property conditions imposed by the contract did not restrict what the firm might have wanted to do in terms of further commercialisation. Three projects did mention the use of their results by non-participants i.e. commercial use by other firms (four in total) outside the project. Three of the four firms are listed in the UK Space directory and the other firm is a major ICT company. However, the value of these results seems not to have been sufficient to justify IP protection.

8.19 To the 'lead' units' knowledge there has been only been four instances amongst the 29 sub-contractors where the sub-contractors themselves used the project results.

8.20 A quite different picture was reported in discussions with the main beneficiaries when looking wider than the project sample or the 5 programmes being reviewed. From these discussions, considering all civil space activities over a considerable time period, long lists of non space applications are reported (in module 3). However, in the absence of more details on causality (and additionality) and the scale of both costs and benefits, the relationship of such evidence to the specific support programmes is, at best, circumstantial.

8.21 We asked interviewees whether they were aware of any new companies that have been established, based largely on technologies or processes or expertise arising from civil space projects, which are principally serving non-space firms. They were able to identify five firms that met these criteria. We also asked if they could identify any such new companies serving military or civil space markets and they mentioned four firms – one of these four grew out of the interviewee's business.

Unease

8.22 One area of unease that we sought to clarify, without a great deal of success, arose from the sense that space industry is rather cliquey, inward looking and focussed on familiar public sector markets rather than possible new market opportunities outside the space sector. The fact that 11 of the 22 projects were undertaken by companies that only operate in the space sector made us question the vigour with which they would pursue the commercialisation of technologies outside the space sector.

non participants

8.23 To explore the unease about the business support programme's only reaching out to a rather narrow group of firms, interviews were held with four firms that might have been expected to benefit from support available from one or other of the programmes but had not done so.

8.24 Whilst the nature of these four non-participants' involvements in the space industry varies considerably all are value added suppliers in the supply chain to create space assets. The products or services supplied by these firms were, in their own words:

- applications side of the ground segment producing enabling technology for people who want to use earth observation data
- small aviation firm which builds and launches rockets
- geographic data and imaging – creation and supply of raw and value added imagery
- designer and manufacturer of consumer electronic accessories for the satellite industry.

8.25 All can be described as small firms with less than 50 employees – two were established in the 1990s, one in the 1980s and one in the 1960s. The three firms that included R&D in their accounts all said that their R&D as a share of turnover was less than 10%.

8.26 Only one of the three firms had received any funding previously from BNSC or ESA. This same firm had also been involved in another BNSC contract in the mid 1990s. Again only this interviewee had heard of any of the three BNSC and two ESA programmes that were the focus of the study (the other firms had no real dialogue or relationship with BNSC or ESA). This same firm had applied to one of the BNSC programmes but the proposal failed on the grounds of being too technology led rather than articulating the market benefit of the work. In the absence of public funding the project has not yet been taken forward.

8.27 The three other firms gave the following reasons for not having applied to BNSC or ESA:

- firm is possibly not in the right market and no programmes match the firm's business – BNSC/ESA seen to be high level, research based, work
- conscious of the amount of paper work and effort that they believe is required to understand the BNSC or ESA procedures and systems
- perception is that if the firm has not already received a BNSC or ESA grant then it is difficult to obtain one i.e. only established firms receive the funding
- the programmes are not fully funded – the firm does not have sufficient funding to invest in R&D spend as it needs to devote resources to product and market development
- firm is better off spending time and effort on genuine and realistic income avenues rather than speaking to BNSC/ESA and completing a proposal, which they have little chance of winning anyway.

8.28 Two of the firms had made other applications to the UK Government for funding – both to non-space related schemes. These included the Small Firms Loan Guarantee Scheme (SFLGS) and the Smart award. For one firm, the reasoning behind not applying for Government funding was due to the firm being well established and successful – not small and not large either.

8.29 The four non-participants mentioned a small number of relationships that they share with other firms or organisations in the space industry. The firms listed included QinetiQ, Invacom, ComSine, InfoTerra and Nigel Press Associates, and ASTOS, the Association of Specialist Technical Organisations for Space. So they were in no sense complete outsiders to the civil space industry.

Overall conclusions

8.30 Our overall conclusion from the survey was that it is in the application of space developed technology, processes and skills outside the space sector that the main potential for generating additional economic benefits from the five business support programmes are likely to be found. On the face of it these might be tapped by:

- spreading the support amongst a larger number and wider variety of firms
- specifically seeking to attract firms that are already active in or are committed to move into non –space markets
- requiring firms in their application to set out their commercialisation strategies for knowledge gained from the project includingwithin this non-space markets
- encouraging lead firms to build ambitious SMEs into their project bids
- encouraging more widespread adoption of a partnership ethos between lead firms and subcontractors.

8.31 All of these suggestions seem to us fit well with some key emerging trends in the sector. There is evidence of reducing specialisation, of greater use of modular and batch production methods, and of increasing attention to cost reduction. This is particularly evident in the telecoms market where satellite based services have to take their place among rival technologies on cost, service quality, and risk just like everyone else. It is apparent in the move towards higher volume production of small satellites which, operating as a cluster, can do the job of a single large more multi-functional satellite; although larger satellites remain important for some functions[13]. It is also evident in the greater use being made in civil and military space developments of commercially off the shelf technologies (COTS) which have the advantage of usually being faster and cheaper even if they have to be adapted for military or space applications.

[13] For example, the requirement to transmit significant levels of power for DTH broadcasting means that large satellites are essential. Changes in technology – such as smaller and more powerful power sources – could change this.

8.32 The significance of these changes is that they are likely to bring about increased opportunities for technological "spin-in" (from non-space to space operations) and spillovers and technology transfer from space to other environments. In other words, the space sector is likely to be increasingly drawn into and integrated with other high technology businesses. Thus, the expectation of the past that the potential for technology transfer from the space sector was likely to be modest is likely to need reconsideration in future and this should be taken into account when reviewing the policy implications that flow from the SQW-SPRU study.

9 How could DTI make changes to existing programmes or reallocate existing spending to maximise the economic benefits from Space investments

9.1 A number of possible changes can be derived directly from the conclusions presented in the last three paragraphs of the preceding section. Before this is done, however, there is a need to venture onto yet thinner ice and consider whether there are other strategic readjustments that should be considered in view of the discussion in earlier sections of global trends and the competitive position of U.K. sectors and firms.

9.2 In heroic summary, the civil space sector has, up to now, seen long cold winters in its markets on account of large and sustained swings in demand (both civil and public). Whilst contra-cyclical public spending is not plausible, there could, however, be public purchasing interventions (as well as science-related expenditures) in relation to certain sub-sectors could help UK firms..

9.3 We mention this with some trepidation for three reasons:

- first, such a purchasing strategy would need to be orchestrated across a number Government Departments and may, therefore, prove infeasible
- second we wonder whether there is a strategic need to wean high potential U.K. upstream space companies away from dependence on public sector contracts and help them to refocus their strategies onto downstream markets and to becoming expert in understanding and responding to the specific characteristics of major downstream customer future needs
- we do not yet know what view will be taken of public purchasing in the DTI's current innovation review (it is not clear that DTI would want to commit its funds in this way given its focus on securing productivity benefits).

9.4 One of the consequences of the industry's long cold winters has been the dominance of the industry by a number of big firms with substantial financial strength. The U.K. market alone cannot, even in the years of greatest plenty, on its own nurture such animals. Upstream U.K. space companies have no option other than to compete globally (in so far as market barriers allow) within their target markets. Their competitiveness can, however, be honed by strategic relationships with demanding major customers who are themselves selling in to major markets. There are such customers based in the U.K. and we are not convinced that potential synergies are being tapped to the full. This may be one instance where the application of cluster 'theory' and practical experience could help to reconsider the appropriateness of Government intervention.

9.5 It is within such wider considerations, which we are not in a position to develop further here, that efforts to strengthen the weight given to broadening the downstream economic and social impact of the space programmes, and to take positive steps towards generating more technological and commercial spillovers and technology and knowledge transfer[14], need to be set.

9.6 Of course there is already acceptance of the desirability of such measures, but our discussions suggested that efforts to secure wider benefits were still something of an "after-thought" and relatively small-scale. In other words, the tendency has remained to think of wider benefits as a bonus. It seems to us that this approach is not consistent with the DTI's current ethos for business support programmes. Rather, it reflects the fact that DTI funding has traditionally been used to procure technologies to further the goals of the wider BNSC partnership. .

9.7 There is, in our view, a case for change so as to secure consistency with the Department's new business support process. This involves elevating wider benefits in the rationale for civil space support and stems from three strategic considerations.

- First, business support of parts of civil space based on their "infant industry" status and on the need to act against the actual and potential dominance of a single global supplier is likely to be more effective if it also enhances downstream user knowledge and systems and not just the provision of space assets per se. In short, defensive investment in space assets needs the complementary capacity to use them intelligently. This suggests that strategic priorities for space support should take into account the UK's current and potential comparative advantage in downstream systems and on the extent to which they can be meshed effectively with its comparative advantage in the provision of space assets.

- Secondly, insofar as it is the case that segments of the space sector are becoming less specialised and more mainstream, then it follows that the potential for wider benefits will be increased. Whilst the market can be expected, in these circumstances, to play an increasingly effective role in generating these wider benefits, it is likely that information deficiencies, high costs and risks, and the presence of externalities may still provide a rationale for business support designed to secure the benefits through technology transfer and other means.

- Thirdly, as the sector matures there will be the increasing potential for new players to enter the market and, to an extent, market forces will facilitate this. However, entry costs are likely to remain high and institutional and cultural barriers to the opening up of the sector will undoubtedly persist. There may, therefore, be a case for ensuring that the

[14] For convenience, we refer to this amalgam of opportunities as "wider benefits".

UK's commitment to ESA is pursued with greater encouragement of competition in procurement and grant provision, the participation of small and medium sized enterprises (SMEs), and collaboration between space businesses and those from other sectors.

9.8 A rationale for business support of civil space along the above lines could give rise to policy developments in the following five domains.

- **Determination of strategic priorities** for business support of civil space: It follows from the above rationale that these support priorities should be informed by an assessment of the current and potential comparative advantage of both UK space businesses upstream and UK downstream suppliers and of the relevance of establishing a mesh between them given trends in demand and competing technologies. This is likely to require a strengthening of the influence that downstream suppliers can exercise in space support strategy and programme development. For instance, one element in such a strengthening could involve changing the composition of the boards that are in place already to advise BNSC on strategic and programme direction or restructuring them to promote a stronger overview and synergy between investment in space assets and their exploitation in other environments.

- **Programme and project specification**: The way that civil space programmes and projects are specified could be reviewed:

  - to provide more meshing of space and downstream technologies (i.e. in pursuit of the strategic priorities generated from the revised mechanisms suggested above)
  - to encourage increased participation of SMEs and
  - to prompt collaboration between space sector businesses and others.

  Specifications designed to do this would be likely to have the characteristics associated with the collaborative R&D Product 6 emerging from the current DTI business support review.

- **Funding terms and conditions**: Programmes and projects revised in the way suggested above would have to be accompanied by complementary funding terms and conditions that tied assistance to activities not traditionally carried out by space businesses (e.g. collaboration with others on more than a sub-contract basis, active engagement in technology transfer). It might also be appropriate to consider terms and conditions that would operate in favour of SMEs (e.g. perhaps through quotas – competitively bid for – and/or more favourable funding terms).

- **Project management**: In the spirit of the other suggested changes, the management of business support civil space projects would have to retain the tightly managed systems and procedures associated with effective procurement at the same time as becoming more transparent and more open to participation by others. ESA contracts already tend in this direction and the practice should be encouraged.

- **Supplementary technology transfer activities**: Consistent with the above changes, there may be a case for pro-active programmes designed to assist the process of technology transfer and knowledge dissemination. The current technology transfer activities of ESA and BNSC could be expanded and enhanced – although the extent to which this should be done is likely to depend on the degree to which the other proposed changes are introduced. If the programmes are specified to include a significant element of knowledge and technology transfer from space businesses to others, then the case for a separate and supplementary transfer programme is likely to be that much weaker.

9.9 The proposed changes would require a shift in culture and in the approach to the design and delivery of civil space programmes – with a more explicit appreciation of the approaches that are taken in other business support programmes outside the space sector.. This might require changes within BNSC (e.g. more industrial and user secondments) so that more emphasis was placed, as a matter of course, on securing wider economic benefits from public sector investment in space assets. We understand that this would fit with the DTI's emphasis on potential spillover benefits in its proposed technology strategy.

9.10 In particular, the adoption of a business support approach would require considerable improvement to BNSC's performance management systems, its monitoring of assistance and the resultant activities, outputs and outcomes. These systems proved ill-adjusted to reviewer's requirements. They would have to be rendered more transparent in terms of the distribution and use of funding, so that any changes in policy could be kept under close scrutiny and modified in response to experience and further developments in external circumstances. Many of these changes would need to be made to deliver the level of monitoring which the new business support process requires. Furthermore, BNSC will have to keep in its sights developments in the market dynamics of downstream market application as well in the wider sphere of global civil space activity.

Tracking wider benefits

9.11 A recurrent theme in the preceding discussion has been the importance of wider benefits when considering the case for project support. Of particular importance are the wider benefits that the originating firm cannot appropriate. If anything, the importance of such wider benefits is likely to increase in the appraisal of projects to be financed through business support programmes. It is, therefore, highly desirable that steps are taken to build an evidence base on such wider impacts. The topics explored in our project questionnaire, notably section c '*outputs and returns from participation in the project*', provide a helpful starting point for a consideration of what coverage may be appropriate.

9.12 So far as process is concerned, we suggest that each appraisal paper on projects to receive business support programme funding should contain a section describing the expected wider impacts from the project. Once approval in principle has been decided, the firm should then be required to produce an action plan for helping to ensure the realisation of the wider benefits and this should be incorporated within the contract with DTI.

9.13 Once the project was underway, each milestone report (at a minimum six monthly) should provide an update on actions, achievements and plans for realisation of wider benefits (which might include benefits to the science base as well as commercial impacts). At the time of the final claim for payment, a fuller action plan should be presented, with an undertaking to report annually on progress until such time as the firm formally reports to DTI that no further efforts to realise wider benefits are worthwhile - alongside a summative completion statement of what has been achieved.

9.14 In the case of projects for which the initial appraisal paper did not specify wider benefits, the topic should be reconsidered at the time of final payment when the firm should be asked to indicate whether or not, in the light of insights gained during the project it now foresaw potential wider benefits and how it could act so as to achieve these.

9.15 Making the process explicit, along these lines, would offer two advantages:

- it would increase the probability of firms paying serious attention to the achievement of wider benefits
- it would provide structured opportunities for the DTI to engage in dialogue with the firms and, if appropriate, suggest that independent expertise be sought to review alternative avenues for exploitation and thereby increase wider benefits (of particular relevance when firms' experience is restricted to space markets).