UK SPACE AGENCY

National Space Technology Programme 2 Evaluation

2018

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Aknowledgements

The UK Space Agency would like to thank

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National Space Technology Programme 2 Evaluation 2018

Final Report

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1 Executive summary

The **National Space Technology Programme (NSTP)** is the UK Space Agency's (UKSA's) national capability-building programme. It seeks to encourage the growth of the UK space technology sector through the provision of grant funding to those looking to develop technology and build new capabilities.

The UKSA commissioned Technopolis to evaluate the NSTP, focusing on its second round of funding (NSTP2, projects launched 2014-2016), and this report presents the findings of that evaluation.

The Evaluation

The **objectives** of the evaluation were to assess the benefit and impacts of the programme, its value for money (costs vs benefits), and the processes by which it has been delivered and implemented.

The study was undertaken between December 2017 and April 2018. The **approach** involved a review of available programme documentation and data, as well as a series of primary data collection activities.

This included: a telephone-based survey of NSTP project leads (50 individuals from 29 organisations); an online survey of NSTP2 partner organisations (with 14 responses); interviews with 6 members of the UKSA and the Centre for Earth Observation Instrumentation – Space Technology (CEOI-ST) programme management teams; and follow-up interviews with 34 individuals at 18 participating organisations. Overall, the study has consulted with 30 participant organisations, covering large and small companies, universities and other public sector bodies, spread across the UK.

The programme

The NSTP provides grant funding to the UK space sector for the development of technologies that are aligned with priority themes identified in the 2014 National Space Strategy. It typically funds projects at low- to mid- Technology Readiness Levels (TRL), helping to accelerate innovation and better position organisations to enter and expand within both institutional and commercial space markets.

The NSTP offers a range of funding opportunities for different types and sizes of projects and actors. Four main **categories of grant** were offered during the second phase, ranging from small (£10k) Grants for Exploratory Ideas (GEIs), through larger Pathfinder (6 months, £50k) and Fast Track projects (12 months and £150k), up to £1m (24 month) Flagship projects. The size and duration of projects increases as one moves through these grant categories, progressing from lower TRLs (e.g. TRL2 – formulation of technology concept) to higher TRLs (e.g. TRL5 or 6, component validation and prototyping). The activities encompass fundamental research, feasibility studies and proof of concept work, through to industrial research and experimental development.

There were 120 **projects** funded during the second phase of the NSTP, with **awards** totalling around £8.4m (an average of £69.3k per project). GEIs accounted for most projects (38%) but

only 5% of the programme budget, while the two Flagship projects funded during NSTP2 were together awarded £2m.

NSTP2 calls were open to all UK industry, Higher Education Institutions (HEIs) and other institutional organisations. Collaboration was encouraged, as were organisations new to space technology. In total, the 120 NSTP2 projects involved 93 separate **organisations** – either as a lead and / or as a partner – and this included 69 companies, 21 universities and 3 other government-funded bodies. Industrial participants ranged widely, from start-ups and SMEs through to £100m+ multinational companies.

Programme impacts

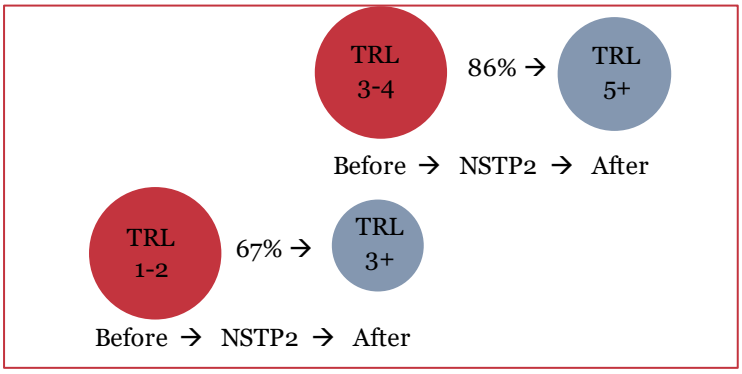
Most NSTP2 projects have only recently concluded or were still ongoing at the time this study was undertaken. Consequently, the programme results presented are often very preliminary and focused more on the immediate outcomes of participation; many of the benefits and impacts will only be realised and fully understood over the course of many more years. Nevertheless, participants were also asked to provide informed opinions about the likely longer-term benefits and impacts of the programme on their organisation and in relation to the specific project idea or technology supported. In addition, there are also examples of strong programme impacts that have already been identified at this early stage.

- **New and strengthened partnerships** - The NSTP seeks to encourage strategic partnerships, including the formation of *new* collaborations and the strengthening of *existing* relationships through projects. With explicit encouragement, half of all NSTP2 projects involved a consortium of UK organisations, with 118 individual collaborations in total. This included 51 instances of industry-industry partnership and 41 instances of industry-academia collaboration. Lead organisations reported that 70% of their project partners were *new* collaborators, and that in all cases, relationships with NSTP2 partners had been strengthened through these projects.

- **Spin-in of organisations to the space sector** - The NSTP encourages proposals from organisations that are new to space. However, the study identified just one such example amongst the organisations consulted. More generally it is clear that NSTP2 has attracted a very wide range of organisations, spanning space manufacturing, applications, operations and ancillary services. There is also evidence that organisations already within the space sector are seeing an increased focus on space-related activities as a result of their participation, with reported improvements in awareness of their organisation and an expectation of increased market share in future.

- **New and improved knowledge, skills and capabilities -** Most lead organisations reported improvements to internal knowledge, skills and capabilities as a direct benefit of their participation in NSTP2. Projects also engaged in various activities to codify, disseminate and transfer knowledge. For instance, amongst 54 lead and partner organisations consulted (representing around one-quarter of all participations) 16 publications in refereed journals and 55 other publications were reported, as well as 7 patent applications. All-but-one lead organisation also reported using NSTP-developed knowledge or technology elsewhere in their organisation.

- **Raising TRL levels** – The study has found that two thirds of projects that were at TRL 1-2 on application, had moved to TRL 3 or above by the end of their NSTP2 funding, while 86% of projects starting at TRL 3-4 had progressed to TRL 5 or above. The NSTP was deliberately designed with a 'tiered' system of grants to enable the same project to progress from receiving a GEI (to formulate a technology concept) to further NSTP funding for R&D (for proof of concept, breadboard validation or prototyping), and then hopefully on to other grant / commercial income sources. There are clear examples of such progression within the wider NSTP portfolio (now 3 rounds), with the programme supporting an idea or technology multiple times as it progresses.



- **Continuation of NSTP partnerships and collaborations** – Nearly all lead organisations intend to work again with their NSTP2 partners after their project (if they haven't already). We estimate that this includes the continuation of 40-50 partnerships that were *newly* established through the programme. Nearly all organisations also reported that NSTP2 participation had increased the attractiveness of their own organisation as a space R&D partner.

- **Increased visibility and reputation of UK capabilities** – Most participating organisations believe that NSTP2 has increased the visibility and reputation of their organisation in the space sector. NSTP2 participation is also felt to have improved these organisations' future-prospects in the space market (increased attractiveness to funders, increased likelihood of securing contracts).

- **Projects de-risked for further investment** – Most leads reported that their project had been de-risked through NSTP2. In addition, two-thirds reported it had resulted in a reduction in the cost of their project idea, while three quarters claimed that it had reduced the time to market.

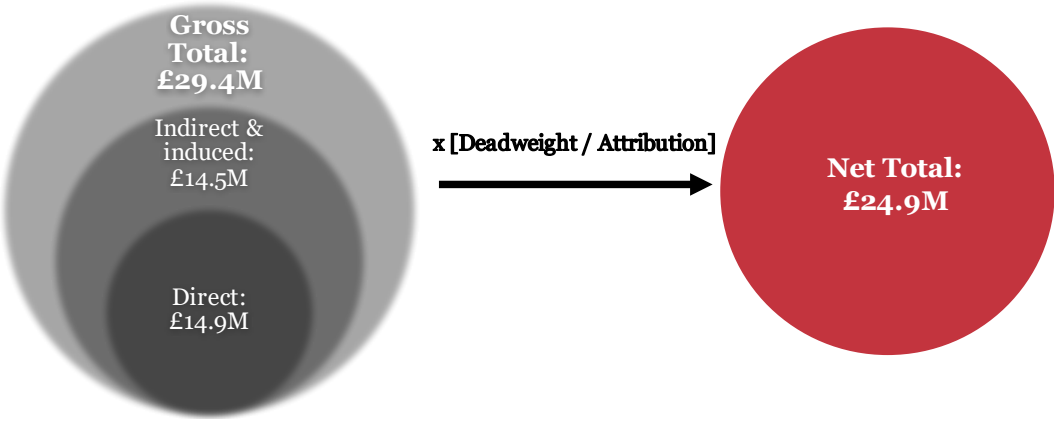
- **Generation of additional contracts and revenue** –Despite most NSTP2 projects only recently concluding, and the fact that most projects were in the lower TRLs, there are already examples of projects generating additional revenue because of developments supported through the NSTP. This is typically another publicly-funded award (e.g. a larger NSTP grant or an Innovate UK collaborative R&D award); there are relatively few instances where projects have so far provided the platform for a winning bid to ESA or NASA - albeit there are one or two notable examples.

  This partly reflects the limited time that has elapsed since the end of projects, but also strong competition for ESA contracts deriving from the substantial space technology capacity and national technology support in key ESA member states (e.g. France, Germany, Italy). In addition, it was always fully expected that, while the NSTP helps technology to move up the TRL scale, further development work may be required before it is ready for commercialisation or use on a mission.

Value for money

Based on the responses of 33 participants, the study estimates that the developments supported through their NSTP2 projects will lead to £40.2M in new commercial and non-commercial revenue. In gross value added (GVA) terms (i.e. added value generated by participants and not simply purchased from the supply chain), this equates to £14.9M in gross direct impact amongst respondents. An additional £14.5M in indirect and induced impacts takes the total gross impact of these 33 projects to £29.4M.

After accounting for deadweight (the fraction of those additional sales likely to have been realised anyway, without the NSTP-2 programme), we estimate the **total *net* impact** of the positive commercial benefits generated by this **sample of 33 NSTP2 participants to be £24.9M.** This figure represents a *minimum*, as it is based only on the observed and anticipated benefits to 33 participants responding to our survey. Impact across the wider portfolio of 120 NSTP2 projects is likely to be much higher.



Based on the public investments made by UKSA through NSTP2 grants (to the sample of 33 projects), the **return on investment** to the programme is estimated to be at least **£7 for every £1 invested**.

The investments made by UKSA have also leveraged funding across participants, which in some cases goes beyond the formal requirements because organisations are prepared to top-up their commitments to drive the project to successful conclusion. We estimate that **each £1 of (public) funding leads to an additional £0.54 in investments from participants** (amongst our survey respondents).

Programme delivery and implementation

Participants reported **widespread satisfaction with delivery and implementation** of the NSTP, including aspects relating to communication, application processes, administrative requirements, funding and project support. Nevertheless, several areas for improvement were suggested:

- An improved online presence for the NSTP, providing information on the objectives and key features of the programme, future funding opportunities and intentions, and past projects / achievements
- A mapping of the wider funding landscape, which would locate the NSTP and explain how it is distinct and where / how it draws on and feeds into other schemes, in the UK and elsewhere

- More regular programme-level events to allow projects to showcase their work to one another and to allow participants and prospective bidders to come together to learn from one another and discuss potential future collaborations and projects
- Improved communication of forward-plans for NSTP funding, including whether / when future calls will be released (ideally on a more regularised basis), what these will cover, and the likely budget
- Increased flexibility as to the scale and timeline of individual grant awards, or the introduction of a new middle-tier funding option (e.g. £20K to £500K and from 6 – 18 months), to better take account of the variable nature of potential projects

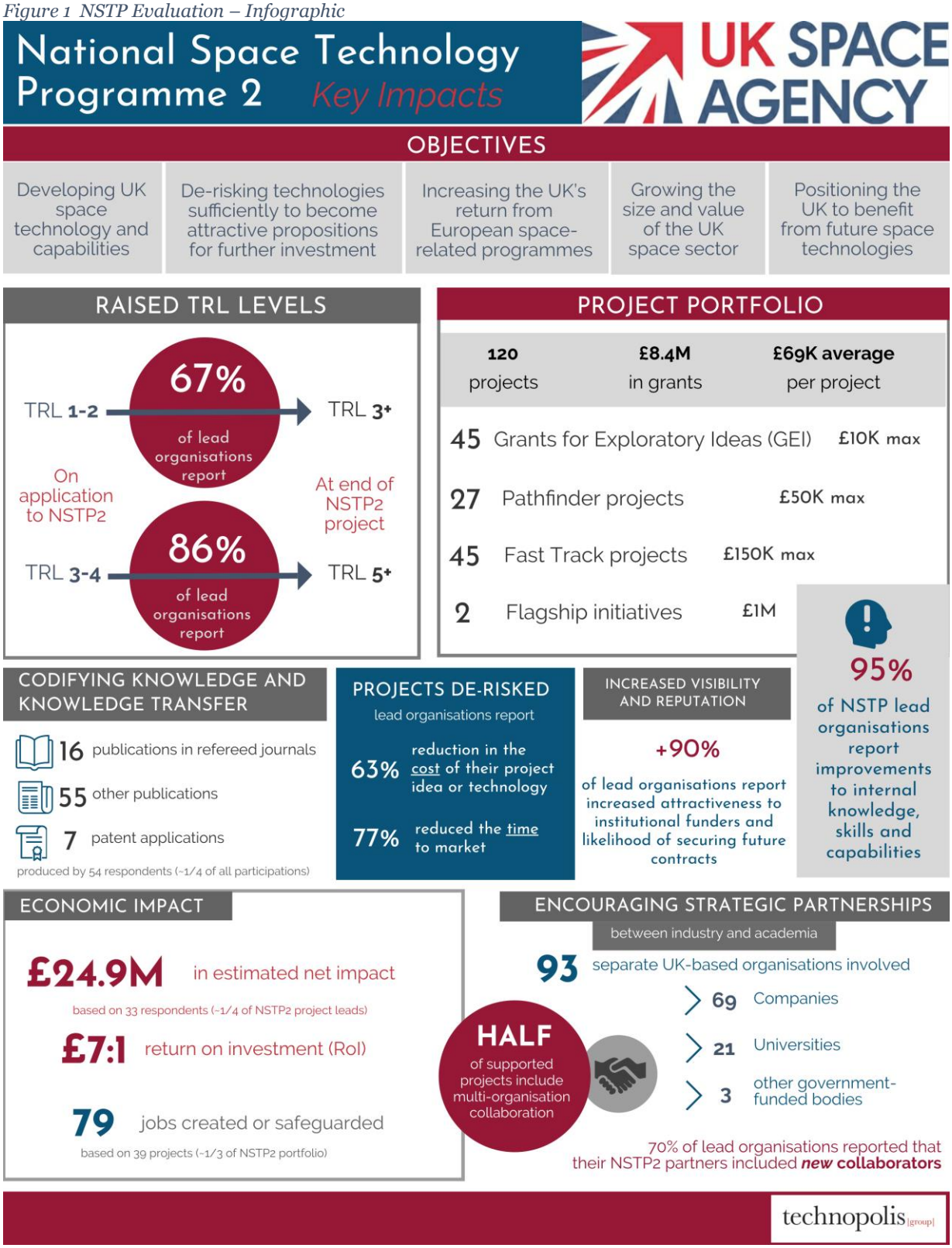
From the perspective of participants, **the NSTP also offers clear value for money**. More than three-quarters of the leads and partners consulted reported that the benefits of involvement in the programme already outweighed the costs to their organisations. They view the NSTP and the opportunities that it provides very positively and **would like to see it continued and expanded**.

There was a consistent and positive view as to the programme's thematic openness and emphasis on a larger number of smaller grants addressing lower TRLs (with higher levels of public funding). The NSTP2 offer addresses an important market failure, where even the largest space companies will focus sharply on their proprietary technology development needs and will rarely fund interesting concepts that sit outside their prescribed strategic technology roadmap. ESA will fund blue-sky technology research, but these projects need to show a clear link with future space missions.

The openness of the programme means that it is creating a diverse and expanding pool of interesting ideas and technologies. However, the programme is not capable of capitalising fully on all of these opportunities. The UKSA might usefully perform an annual strategic review of its project portfolio, looking for the best means of moving promising ideas and technologies forward, through whatever means (e.g. via follow-up grants, or through signposting to alternative funding). Additional funding for definitional work might then also help to support successful applications to other funding sources.

Finally, there are substantial costs and risks associated with progressing novel technologies from mid-TRL validation to higher TRL in-flight demonstrations and on to commercial sales. Even the largest space companies will struggle to underwrite these additional costs, except where the technology aligns closely with ESA or NASA roadmaps and there is a reasonable prospect of winning a major contract to test and demonstrate the system on a specific mission. Many NSTP technologies are novel in concept and as a result have limited heritage and will, by definition, struggle to make a case for inclusion within ESA or NASA missions. There were therefore also regular calls from amongst NSTP2 participants for UKSA to look for ways to improve opportunities for demonstration flights for UK organisations.

Figure 1 NSTP Evaluation – Infographic



2 Introduction

The evaluation

This document presents the Final Report from the evaluation of the National Space Technology Programme (NSTP), which Technopolis have undertaken on behalf of the UK Space Agency (UKSA) between December 2017 and April 2018. There were three main elements required of the study:

- An impact evaluation - What difference did funding make? What benefits and impacts have been achieved – amongst grant recipients, and for the skills base, space sector and economy more widely?
- A value for money assessment - How do costs and benefits compare? Do the benefits justify the costs and therefore to what extent does the programme represent value for money?
- A process evaluation - How effectively and efficiently was the programme delivered and implemented? What are the barriers and drivers to programme effectiveness and efficiency?

A review was already undertaken in 2014 of the first round of funding (NSTP1), and so the current evaluation was to look primarily at the impact of the second round of the programme (NSTP2) and the projects funded during this period (those launched 2014 to 2016). However, as technological-based programmes often do not reveal their true total benefits for many years, we also looked at a selection of NSTP1 projects, to better understand the likely the longer-term impacts of NSTP2 funding.

The approach

A mixed-method approach was employed, organised around four main packages of work:

- WP1: Scoping – A short inception period, to review available programme documentation and data, develop the programme logic model and evaluation framework, and finalise the evaluation approach
- WP2: Primary data collection – The main phase of evidence gathering, including surveys of grant recipients, as well as interviews with participating organisations and programme management.
- WP3: Analysis – A final phase, drawing together and analysing the various available information and evidence gathered through the study to address each of the key requirements and questions.
- WP4: Reporting – Throughout the study, a series of reports and meetings have provided updates on study progress and details of emerging findings. This report represents the final deliverable.

Programme documentation and data available to the study team was limited, and so the approach relied heavily on a series of primary data collection activities. This included:

- A telephone-based survey of NSTP project leads (50 individuals from 29 organisations)
- An online survey of NSTP2 partner organisations (16 responses received)
- Interviews with 6 members of the NSTP2 programme management team at UKSA and CEOI-ST
- Follow-up interviews with 34 individuals at 18 participating organisations.

Further details of the study requirements, approach and methods are provided in Appendix A.

This report

The remainder of this report is structured as follows:

- Section 3 – introduces the NSTP and the aims and intentions of this programme, before presenting a brief overview of the projects and beneficiaries funded through NSTP2
- Section 4 – presents the results of the impact evaluation, which are organised according to the main areas of intended outcomes, benefits and impacts the programme
- Section 5 – provides an overall assessment of the programme's value for money, based on the estimated value of contracts resulting from NSTP2 projects and the effects of these on the economy
- Section 6 – assesses various aspects of the delivery and implementation of the programme
- Section 7 – draws together the main findings in a concluding chapter, which also suggests further areas for programme improvement moving forwards

3 The National Space Technology Programme

3.1 Background and context to the NSTP

More than fifty years ago, Britain became the third nation to launch a satellite, Ariel 1. It has since participated in numerous science missions, while its space industry has grown to £13.7 billion. Space technology has also become critical for providing UK citizens and businesses with the infrastructure that underpins societal and economic wellbeing, from global communications and navigation networks, to weather forecasting and environmental monitoring, to support for security and defence.

After "a long spell without clear direction for the sector"[1], the UK Government has published several **space strategies** since 2010. The Space Innovation and Growth Strategy (SIGS) was conceived in 2010, setting out a partnership between industry, government and academia to develop new space related opportunities. This led to the creation of the UK Space Agency (UKSA), as well as the Space Leadership Council, Satellite Applications Catapult and the UK Space Gateway at Harwell. The SIGS was followed up with an Action Plan in 2014, and an update in 2015. In 2012, UKSA published a Civil Space Strategy, along with sector-specific strategies, and in December 2015, the government published its first National Space Policy, which includes the aspiration to establish a UK spaceport.

The UK Space Agency **(UKSA)** sits at the heart of efforts to explore and benefit from space. It works to both showcase UK investment and ensure this brings about real benefits. Its programme budget in 2016/17 was £356m, with around 80% of this allocated to the European Space Agency (ESA) [see below].

UK Membership in ESA

The UK's involvement with ESA has increased over recent years. Responding to the SIGS call to reach average levels of investments (about £400m) by 2020, the UK Government raised its contributions from £220m in 2010 to £300m in 2015, and then 2016 announced an allocation over the five years of more than €1.4 billion. The UK is now the fourth biggest contributor to

[1] House of Commons Science and Technology Committee, Satellites and space 3rd Report of Session 2016–17

ESA (€300m or 7.9% of ESA's funding from Member States in 2017). France and Germany contribute ~23% each and Italy 15%[2].

This visible commitment to ESA is thought to have improved the UK's credibility in the European space sector and given it a "stronger voice" within ESA. Early evidence of this includes the expansion of the ECSAT operations at Harwell, Major Tim Peake's mission to the ISS, and the appointment of a British national as ESA Director of Human Spaceflight and Robotic Exploration.

ESA's annual budget (€5.75 billion in 2017) includes €3.78 billion from member governments, plus €1.7 billion from the EU (mainly to manage Galileo and the Copernicus EO network). About 85% of this is spent on contracts with European industry[3]. The value of membership is often much greater than fair return; with investments into ESA programmes resulting in returns of over £10 per £1 invested[4].

The remainder of UKSA's programme budget is used to finance a range of smaller programmes, including the National Space Technology Programme (NSTP). Compared to other major countries in Europe (France, Germany, Italy, etc.), the UK's domestic space programme is relatively small. Consequently, the UK space sector is relatively commercially-focused, generating just 14% of its income from the public sector (3.1% from space agencies – mainly ESA), compared to a global average of 24%.

The **UK space sector** now contributes £13.7 billion a year to the economy, with an estimated annual growth rate of 6.5%, and directly employing 38,500 people (2014/15)[5]. The UK has also become a recognised leader in the development of (small) satellites, drawing on its strong space research base.

However, the SIGS Action Plan has set an ambitious goal for the UK to capture 10% of the global market for space by 2030 (~£40 billion). This is to be achieved (inter alia) by developing new high-growth markets; pursuing initiatives to grow exports; and increasing the UK's returns from Europe.

It has been recommended that the UK pursue an expanded **national space programme**, to strengthen UK industry's position against leading European space nations, with their large, established space programmes. This would provide UK industry with a competitive advantage when bidding for European or global contracts and help secure an (even) greater return on its contributions to ESA. The UKSA's NSTP was conceived as a foundation for such a strengthened national space programme.

3.2 Programme aims and objectives

The UKSA's National Space Technology Programme (NSTP) is the UKSA's **national capability-building programme.** It seeks to encourage the growth of the UK space technology sector through the provision of grant funding to those looking to develop technology and build new capabilities for the UK space sector. It typically focuses on funding

[2] http://www.esa.int/About_Us/Welcome_to_ESA/Funding

[3] ESA presentation "United Space in Europe" (September 2017)

[4] London Economics (2015) Return from Public Space Investments

[5] The size and health of the UK space industry (December 2016)

lower TRL projects[6], helping to accelerate innovation and better position organisations to enter and expand within institutional or commercial space markets.

The **objectives of the NSTP** are to develop space technology and capabilities to drive growth in the UK economy. More specifically, the main intentions of the NSTP were to:

- Encourage strategic partnerships across industry and with academia, that enhance UK capabilities
- Raise technology levels and de-risk projects, to make them more attractive for further investment
- Use government funding effectively, complementing existing funding schemes and bridging the gap between pre-commercial early stage ideas and their commercial, scientific or societal exploitation

The NSTP offers a range of funding opportunities for different types and sizes of projects and actors. **Four main categories of grant** are now offered, which are summarised in the table below. As can be seen, the size and duration of projects increases as one moves from GEIs to Flagship projects. The eligible activities also evolve, from mini studies (GEIs) to industrial research and experimental development (Flagships), although there is some overlap between the different schemes (particularly Pathfinders and Fast Track projects). The final column summarises other key features of each scheme, which provide further indications of the varying intentions of each type of NSTP grant.

Table 1 NSTP grant schemes – overview of key features

Scheme	Grant	Duration	Acceptable / eligible activities	Intended scope / stage
Grants for Exploratory Ideas (GEI)	£10k max (seed funding)	3 months max	• Mini studies (proof of concept, idea refinement, market survey)	• Early stage / TRL innovative ideas
Pathfinder	£50k max	6 months max	• Fundamental research • Feasibility studies • Industrial research • (limited) technology demonstration	• Highly innovative projects that introduce technologies with disruptive or enabling potential (improving performance / system parameters) • Accelerating the development of space technologies, with credible benefit to future commercial, operational or scientific mission objectives
Fast Track	£150k max	12 months max	• Feasibility studies • Industrial research • Technology demonstration • Experimental development	
Flagship	£1m	24 months	• Industrial research • Experimental development	• Develop technologies to a high TRL (usually TRL 5+) • Offer significant commercial opportunity • Have a clear exploitation route

Source: Based on text of NSTP2 call for projects for each sub-programme.

Across all four schemes, projects are also required to align with priority **technology themes** identified in the 2014 National Space Technology Strategy. In addition, individual calls suggest other elements will be looked on favourably by UKSA, such as:

- Pathfinder projects developing instrumentation for commercial applications
- Fast Track projects developing technologies for commercial applications and / or export markets

[6] Although grants for Flagship projects typically seek to develop technologies to a TRL of 5 or above.

- Pathfinder / Fast Track projects exploiting the capabilities of the Satellite Applications Catapult
- Flagship projects that results in new products, and those demonstrating an urgent need for funding to access an important mission or business opportunity (taking precedence over proposals addressing more speculative objectives)

Calls are open to all UK industry, Higher Education Institutions (HEIs) and other institutional organisations. However, there is an expectation that Flagship projects will be led by industry (unless others can demonstrate that they can deliver a viable route to market). In addition, the calls (except Flagships) specifically encourage participation from organisations that are new to space technology. Collaborative teams, particularly industry-industry and industry-academia, are also encouraged.

There have been **three rounds of NSTP funding.** The first (NSTP1) was launched in 2011, with the first awards made in 2012. It was delivered through a wide-ranging portfolio of funding elements, defined by size of awards and TRL levels, rather than technology areas. This included 4 Flagship, 28 Fast Track and 10 Pathfinder projects (alongside others). Co-funding from industry, the Engineering and Physical Sciences Research Council (EPSRC), the Defence, Science and Technology Laboratories (DSTL), the Technology Strategy Board (TSB, now Innovate UK) and the Science and Technology Facilities Council (STFC), meant that the £10m programme arrived at a total volume of £27m. In January 2013, £25m was announced for a second phase of the programme (NSTP2). A first allocation of £5m was given to 'PRS pilot projects', to position the UK to exploit the market enabled by the Galileo signal. (These pilot projects are outside of the scope of the current evaluation). The next call was released in July 2014, with NSTP grants falling into the four categories described above. NSTP2 was delivered externally by the Centre for Earth Observation Instrumentation – Space Technology (CEOI-ST)[7]. A third phase of programme funding (NSTP3) is ongoing at the time of writing.

3.3 Programme Logic Model

Based on evidence obtained through desk research and discussions with UKSA, the study has developed a logic model for the NSTP (see Figure 2). This sets out the logical sequence and causal relationships among: the aims and objectives for the programme; the resources (inputs) used and the activities undertaken; and the results (outputs) and changes (outcomes and ultimately impacts) that it is hoped or intended will be realised – which should in turn contribute towards addressing the initial objectives.

The model is presented at the overall programme level only. While activities within the four individual funding streams may differ slightly (see Table 1), and the size and scale of individual projects and their ambitions may also vary accordingly, the types of benefits (outputs, outcomes and impacts) being sought are the same across the different parts of the programme. That is not to say that all individual projects are expected to realise *all* of the benefits presented in the model, but – wherever they sit within the programme – their individual 'logic' should fit within this overarching framework.

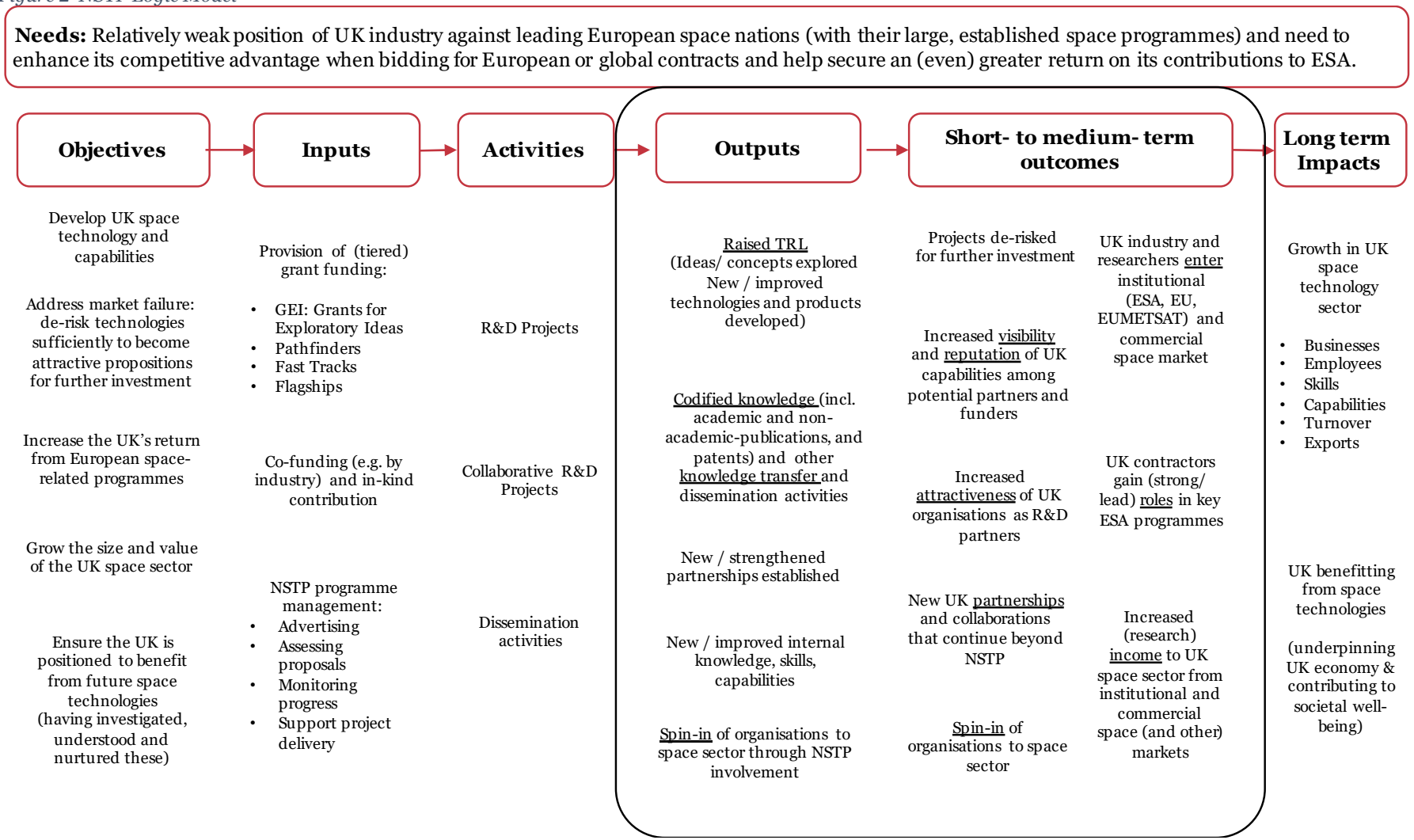
3.4 NSTP2 project portfolio

UKSA provided the study with basic information (title, abstract, value and lead organisation) for each of the NSTP2 grants awarded. Additional information on participants and projects

[7] Partnership of Airbus Defence and Space Ltd, QinetiQ, the University of Leicester and STFC Rutherford Appleton Laboratory.

(the rationale, alignment with Technology Roadmap Themes, co-funding, the start and end TRL, anticipated impacts) is provided as part of the programme application process, but these details could not be shared with the study team for confidentiality reasons. As such, only a basic overview of the project portfolio is possible.

Figure 2 NSTP Logic Model



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There were 120 **projects** funded during NSTP2, with awards totalling £8.4m. However, projects and funding were not evenly distributed across different grant types. The Grants for Exploratory Ideas (GEI) accounted for most projects (38% of the total portfolio), but their small size (<£10k each) meant that they collectively accounted for only 5% of programme spend. By comparison, the two Flagship projects were awarded nearly a quarter (24%) of all NSTP2 funding. The largest volume of funding (£4.7m) went to Fast Track projects, with an average of £103k being awarded to each of 46 projects.

Table 2 Overview of the NSTP2 project portfolio – projects and funding by type

Project Type	Number of Projects	Total awarded	Average award
GEI	46	£438,761	£9,538
Pathfinder	27	£1,191,848	£44,143
Fast Track	45	£4,650,063	£103,335
Flagship	2	£2,000,000	£1,000,000
NSTP2 - Total	**120**	**£8,280,672**	**£69,006**

Each NSTP2 project is led by a single organisation. Some of these **lead organisations** have led multiple projects, so the number of *unique organisations* leading the 120 NSTP2 projects is just 56. Most of the organisations (75%) are from industry, while academia (universities) represent just under a quarter (21%) of the total. The remaining two leads (2%) are government-funded bodies. There are 34 organisations that led just one NSTP2 project, and a further 15 that have led two or three. The remaining seven organisations account for 50 projects between them, leading 4-11 projects each.

Most NSTP2 projects involve other **partner organisations**, but it is more difficult to assemble details of these. Lead applicants are asked to provide details of partners within their proposal, and UKSA have extracted this information for the study – however there may be some gaps or inaccuracies in the data. Around half of NSTP2 projects (59 of the 120) are believed to have involved one or more other partner organisation (beyond the lead applicant). Those without partners tend to be GEIs. There are 85 partners in total across the 61 projects in question, which includes 58 *unique* organisations (69% industry, 26% academia, 5% other). One-third of these partners have also served as NSTP2 leads on other projects, but there are 37 organisations that were only involved as partners in this phase of the programme.

Overall, 93 separate organisations are known to have participated in NSTP2 – either as a lead and / or as a partner. This includes 69 companies, 21 universities and 3 government-funded bodies.

Table 3 NSTP2 – all participating organisations – by organisation type and project role

Type	Unique Organisations	Participations Total	Project lead role	Project Partner role
Industry	69 (74%)	134 (65%)	83 (69%)	51 (60%)
Academia	21 (23%)	54 (26%)	28 (23%)	26 (31%)
Other	3 (3%)	17 (8%)	9 (8%)	8 (9%)
All	**93**	**205**	**120**	**85**

The companies leading NSTP2 projects range from SMEs with turnover in the tens of thousands of pounds, to large multinationals with £100m+ turnover[8], with activities (self-

[8] Information obtained from the FAME company database.

reported) spanning space manufacturing (48%), applications (23%), operations (3%) and ancillary services (23%). Most of these companies fall within two broad SIC codes: professional, scientific and technical activities (27 companies); and manufacturing (20 companies). However, other sectors are also represented, including information and communication (7), civil engineering (1) and business support activities (1)[9].

4 Impact evaluation

This section concerns the assessment of the impact of NSTP2. The overall purpose of the impact evaluation was to understand what difference the programme funding had made, in terms of the benefits and impacts for grant recipients, as well as for the UK skills base, space sector and economy more widely. As some NSTP2 projects have only recently concluded, it considers both achievements realised to-date, as well as likely future benefits and impacts that are expected. We also look to the experience of NSTP1 projects to get a sense of the longer-term prospects for NSTP2 projects.

The section is structured around the main outputs and outcomes that were intended or expected from NSTP funding (see programme logic model, Figure 2), drawing mainly on the evidence collected through surveys and interviews with grant recipients and their project partners. The telephone survey of project leads and online survey of partners both asked about the extent to which a range of outputs, outcomes and benefits had been realised, or were anticipated. A selection of the results are highlighted in this section. The follow-up interviews with participating organisations then explored some of the benefits and impacts in more depth. Specific examples and quotes taken from these discussions are presented below to exemplify the types of benefits and impacts realised as a result of the programme.

It is important to stress that at the time that NSTP2 participants were consulted for this study, most projects had only recently concluded or were still ongoing[10]. This means that the results presented are often very preliminary and focused more on the immediate outcomes of participation; many of the benefits and impacts of the programme will only be realised and fully understood over the course of many more years. While we have asked participants to provide informed opinions about longer term benefits and impacts of the programme on their organisation and project idea / technology, there are obviously going to be limits on the extent to which respondents can know what the future holds.

4.1 New and strengthened partnerships

The NSTP seeks to encourage strategic partnerships across industry, as well as between industry and academia, that enhance UK capabilities. As such, collaborative teams, particularly industry-industry and industry-academia, are explicitly encouraged within the calls for NSTP proposals. It is hoped that NSTP funding helps to both encourage **new partnerships to be formed** and for **relationships to be strengthened** through the course of the NSTP projects, with longer-lasting benefits.

[9] Information obtained from the FAME company database. Not all companies could be identified within the database, hence the total number of organisations with SIC codes (56) is lower than the actual number of participating organisations (69).

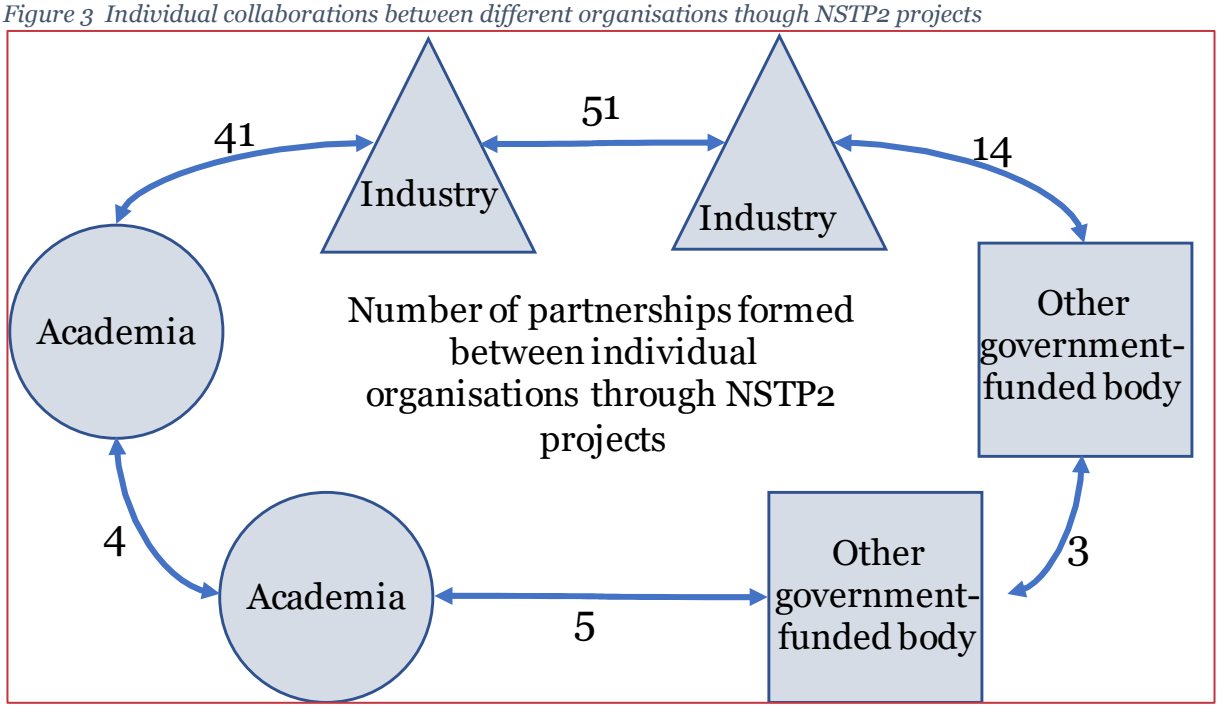
[10] For example, the lead and partner surveys asked respondents about a specific NSTP2 project. In 15% of these cases the project was still ongoing, or had just concluded at the start of 2018. A further 33% were asked about projects that had only concluded within the previous 12-months, while only half 52% were asked about projects that had concluded earlier.

Half (n=59) of the portfolio of NSTP2 projects are thought to have **involved a consortium** of more than one organisation. Indeed, according to the NSTP2 database, 33% of projects involved two organisations, 13% involved three and 4% involved four or more different partners.

Most of the projects that involved just a single-organisation (39 of 59 such cases) were funded through the Grants for Exploratory Ideas, where the small scale (<£10K, <3 month) means that partnership-working will often have been less appropriate. For other grant types, **the majority (73%) of projects involved multi-partner collaboration** (a lead plus one or more partner organisations).

Across the NSTP2 portfolio, **118 individual collaborations** were formed. This included (see Figure 3) 51 instances of industry-industry partnership (which took place within 25 of the projects), 41 instances of industry-academia partnership (within 33 of the projects) and 14 instances of industry partnering with other government-funded bodies (within 9 of the NSTP2 projects).

Figure 3 Individual collaborations between different organisations though NSTP2 projects



Technopolis analysis of NSTP2 project database

NSTP2 lead organisations were asked through the survey whether any of their partners were *new* (i.e. they had never worked with them before the project). The majority (80%) of leads that had partnered with another organisation indicated that *at least one* of their partners was new, and that overall **70% of their partners were new collaborators**. If this were to hold across the wider portfolio of 61 multi-partner projects, then NSTP2 leads will have partnered with around 59 *new* collaborators in total.

The UKSA role in encouraging new collaborations was felt to have been important in several cases: *"We may not have developed it as a partnership – with a private sector organisation – if the UKSA hadn't pushed for this."* It was also generally seen as a positive aspect of programme involvement, with clear benefits: "*We worked with a company that we had never*

worked with before, and this provided a link into other companies, as well as exposure to a whole new community"; "The project brought us into a manufacturing community, helping to create business links"; "This was our first collaborative innovation project, and it helped us learn how to work with partners – both now and in the future".

All of the **partner organisations** responding to our survey had (by definition) worked with at least one other organisation through their NSTP project. Between them, the 14 responding organisations had worked with a total of 23 partners within these projects. Half (50%) said that their consortium included at least one partner that they had never worked with before, and these seven respondents reported nine new partners in total. If these responses are representative of the population more broadly, then we can estimate that of the 85 partner organisations involved in NSTP projects, **over 40 will have been collaborating with a *new* partner in their project** (with 40-50 new partners in total).

All of the lead organisations that had worked with at least one partner in their NSTP2 project reported that their **relationship with the partner(s) had been strengthened** during the project. They were split relatively evenly between those who felt the relationship had been strengthened 'to a small extent' (45%) and those who felt it had been strengthened 'to a large extent' (55%). Nearly all partner organisations surveyed (93%) similarly reported strengthened relationships through their projects.

For some participants, the strengthening of relationships has been one of the most important benefits of their NSTP2 involvement: *"One of the most significant benefits has been that the project enabled the university to establish and consolidate a research relationship with [project lead]. This has resulted in a proposal for a Marie Curie Network and a new PhD in collaboration with the company."*

4.2 Spin-in of organisations to the space sector

The NSTP calls explicitly invite proposals from organisations (academia and industry, including SMEs) that are new to space technology (i.e. **spin-ins from outside of the space sector**). This is particularly encouraged for early stage innovative ideas (i.e. proposals for GEI funding).

We asked through the consultations whether organisations had worked in the space sector before their NSTP project, but found little evidence amongst this sample of spin-ins. Of the 50 NSTP1/2 leads and 15 NSTP2 partners covered, only one said that they had not worked in the sector before the project. This partner - a micro company specialising in 3D metal printing - was invited to collaborate with a major UK engineering firm on a Pathfinder project that sought to explore recent developments in additive manufacturing and their applicability for creating bespoke high-performance space components.

The "spin-in" company reported to the study team that the NSTP2 grant had allowed them to explore a novel metal process, which developed knowledge within both partner organisations and had allowed them to consider new product paths. The R&D in the project has already supported product development in other areas of the organisation and it is optimistic about further opportunities in the future. The company Director also reported that involvement had allowed the organisation *"to meet other companies in the space industry… we want to expand into space, but this will take time".*

Although we have only identified one example of a spin-in to space through NSTP2 projects, it is also clear that the programme has more generally attracted a very **wide range of participating organisations**. This includes 69 companies, 21 universities and colleges and

three other public research bodies. The companies range from SMEs with turnover in the tens of thousands of pounds, to large multinationals with £100m+ turnover[11], with activities (self-reported) spanning:

- Space manufacturing – the design or manufacture of equipment and subsystems (48%)
- Space applications – the development of applications for satellite signals and data (23%)
- Space operations – the launch and/or operation of satellites and/or spacecraft (3%)
- Ancillary services – such as research, design and advice (23%)

Most of the lead organisations fall within two broad SIC codes: professional, scientific and technical activities (27 companies); and manufacturing (20 companies). However, other sectors are also represented, including ICT (7), civil engineering (1) and business support activities (1).[12]

There is also evidence that many organisations – although they already operated within the space sector – are seeing an **increased focus on space-related activities** as a result of their NSTP participation. As will be discussed in more detail later, nearly all project leads report that participation in NSTP2 has improved the reputation and awareness of their organisation within the space sector. In addition, 84% of NSTP2 leads and all NSTP2 partners consulted believe that NSTP participation will increase their market share in the space sector to some extent.

4.3 New and improved knowledge, skills and capabilities

Investigating and understanding technologies, plus creating new and enhanced capabilities within the UK space sector, sit at the heart of NSTP intentions as the national capability-development programme.

Most NSTP2 lead organisations (95%) reported **improvements to internal knowledge, skills and capabilities** as a direct benefit of their participation in their NSTP project – including 78% who said that this had been realised 'to a large extent'. Similarly, all surveyed project partners reported improvements in these areas as a result of their participation, with 92% reporting 'large' improvements.

Improved knowledge and skills not only came about through the research itself, but also through transfers of knowledge between the participating organisations: *"The project has allowed us [a manufacturer] to access knowledge that sat within universities and was new to the company."*

The benefits of new and improved knowledge and skills then play out in several ways across participants. For instance, through spill-overs to other areas of the business: *"The main benefit has been an increase in the skills and capabilities of staff to carry out this form of manufacturing, which will have uses for developing other products"*, or through an increased ability to obtain future funding and contracts: *"We have received grants linked to expertise gained through the project"; "As a result of our involvement, we are more aware of what the market requires and can work more closely with industry."*

[11] Information obtained from the FAME company database.

[12] Information obtained from the FAME company database. Not all companies could be identified within the database, hence the total number of organisations with SIC codes (56) is lower than the actual number of participating organisations (69).

4.4 Codifying knowledge and knowledge transfer

While much of the new knowledge, skills and capabilities developed through the projects will rest within the organisations and staff concerned, projects also engage in various activities to codify, disseminate and transfer the new knowledge developed beyond the specific project and outside of the organisation.

All-but-one of the lead organisations reported that they had **used NSTP-developed knowledge or technology in other areas of their organisation,** while two-thirds of partner organisations reported doing so. For example: *"We were not the lead partner in this project, but our R&D experiences here are supporting product development in other areas of the business."* All other lead and partner organisations expect to use knowledge or technology developed in other areas of their work in the future.

Lead and partner organisations were also asked through the surveys to indicate which (and how many) of a range of outputs had been produced by their organisation during their NSTP2 project. The following table summarises the information provided by 54 respondents (note, this only relates to around one-quarter of the estimated 205 participations overall). It shows that these participants produced **16 publications in refereed journals** and **55 other publications**, as well as **7 patent applications**.

Table 4 Publications and patents produced by project participants

Lead organisations	Number reporting output	% of all respondents	Total number of outputs	Average production
Publications in refereed journals	5	12%	11	0.3
Other publications	17	41%	36	0.9
Patent applications	4	10%	7	0.2
Partner organisations	Number reporting output	% of all respondents	Total number of outputs	Average production
Publications in refereed journals	4	31%	5	0.4
Other publications	7	54%	19	1.5
Patent applications	0	0%	0	0.0

Surveys of project leads (n=41) and project partners (n=13)

In addition, survey respondents mentioned other project outputs that support the codification and transfer of knowledge generated through the projects. For example:

- A PhD started in collaboration between an academic and industrial partner (and building on the outcomes of the NSTP work)
- A course at ESA-ESTEC updated with results from the NSTP project
- Three contributions to standards
- Presentation at 2017 AAS/AIAA Space Flight Mechanics Meeting Conference in San Antonio, USA

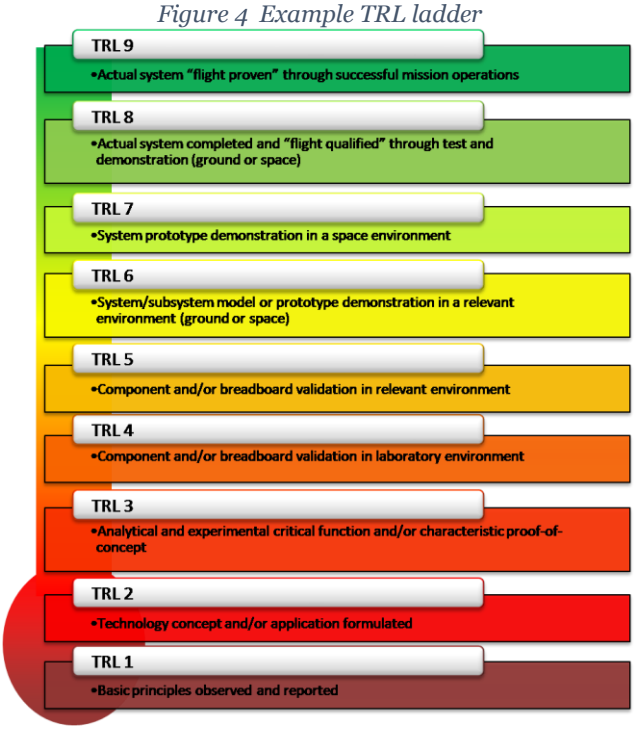
Further, all projects are expected to produce a final report and executive summary that are suitable for publication. There have also been project presentation days in which those funded through the NSTP are invited to present a summary of their work and achievements.

4.5 Raising TRL levels

The NSTP seeks to **support the development of technology and ideas**, helping to accelerate innovation and to progress products up the Technology Readiness Level (TRL) ladder, so as to make them more attractive for further investment (positioning for ESA funding or more commercially viable).

The programme focuses on funding lower TRL projects[13], helping bridge the funding gap between pre-commercial, early stage ideas and their commercial, scientific or societal exploitation. It can take years or decades to develop space technologies, with high levels of risk and uncertainty involved (particularly in the early stages). The NSTP therefore seeks to address a market failure in space sector development, creating benefits that may not be realised if left to market-pull and private sector investment alone.

Figure 4 Example TRL ladder



Source: NASA

The programme call documentation provides indications of the intended scope of the different NSTP grants (although this is only guidance):

- GEI: early stage / TRL innovative ideas
- Pathfinder: typically looking to develop technology to TRL 2-3
- Fast Tracks: typically seeking to develop technology up to TRL 4-5
- Flagships: developing technologies to a high TRL (typically TRL 5+)

NSTP proposals are asked to specify the start and end TRLs of the intended work, however this information was not available to the study (and, in any case, only provides intentions). As such, surveyed lead organisations were asked to provide information on the TRL of their project at the time of application and at the end of their grant (or the expected level, if the project was still ongoing).

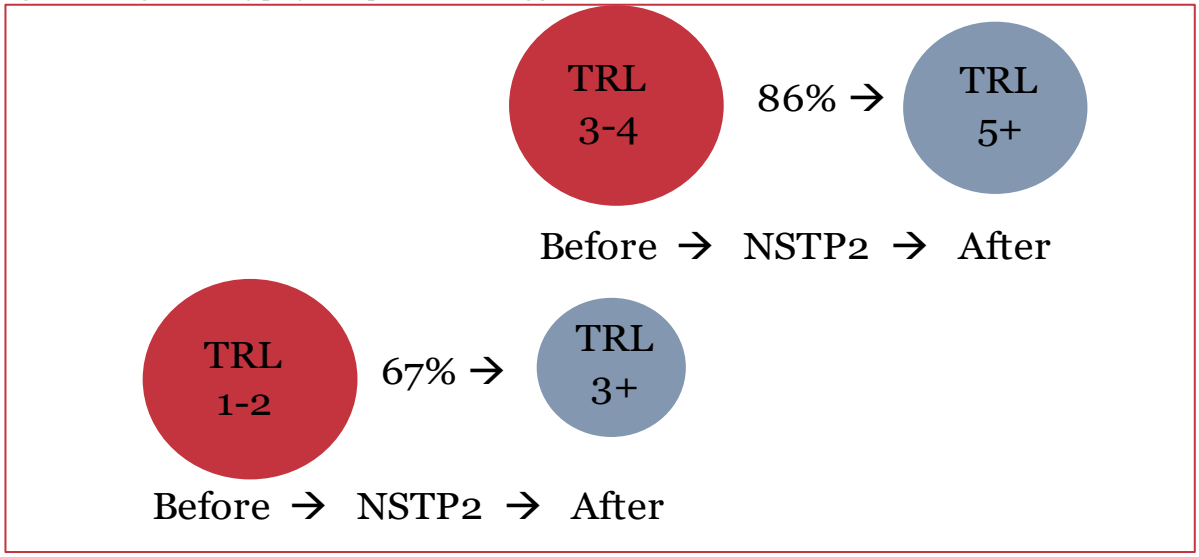
The responses showed that NSTP2 funding has clearly supported the widespread development of ideas and technologies and the **progression of projects/products up the TRL ladder**.

[13] Although grants for Flagships typically seek to develop technologies to TRL 5 or above

Three quarters of respondents (75%) indicated that at the time of application, their project was at TRL 1-2. Of these, two thirds (67%) reported moving to TRL 3 or above by the end of the project (Figure 5).

Of the 20% of project leads reporting a TRL 3-4 at the start of their project, an even greater proportion (86%) had progressed to TRL 5 or above by the end of their grant. These results align with the NSTP1 Review, which found the programme had "raised the TRLs of a wide range of technologies by 1-3 levels".

Figure 5 Progression of projects up the Technology Readiness Level ladder



Survey of NSTP2 lead organisations (n=36)

There are also examples of the programme supporting an idea or technology multiple times as it progresses (often across different rounds of NSTP funding). The NSTP was deliberately designed with a 'tiered' system of grants, to enable the same project lead to progress from receiving a GEI (to formulate a technology concept) to further NSTP funding for R&D (for proof-of-concept, breadboard validation or prototyping), and then hopefully on to other grant / commercial income sources. We have also heard of UKSA encouraging certain proposers considering a Pathfinder grant (for example) to first apply for a GEI in order to explore and develop their idea further before requesting more significant funding.

In example, a small start-up company was awarded an initial £10K grant (GEI) through NSTP1 to explore the potential of a specific application of light-field imaging as a simple, robust means by which to visually check samples collected in space. The success of this first project then led to the award of a second £93K Fast Track grant through NSTP2 to develop the technology for use in in-situ microscopy of scientific samples. This then provided the opportunity for the company to become involved with a UK university that was developing a mass-spectrometer (ProSPA) for use (measuring volatiles like water or CO2) on the ESA-Roscosmos mission to the Lunar south pole (2021). To minimise development timescales, the mission relies heavily on proven, heritage systems, and the NSTP GEI and the Fast Track projects were critical for showing ESA and the University that the new imaging technology is 'safe'.

In another example (which extends beyond the NSTP), a consortium of UK companies benefited from a small NSTP-1 feasibility grant, followed by a slightly larger UKSA CREST award to develop a Lightweight Advanced Robotic Arm Demonstrator (LARAD) to address some of the underlying challenges related to both the design as well as operation of long arms.

This next award has led to a third award, this time from Innovate UK, for a 10-month £128k feasibility study, to use LARAD technologies to demonstrate the construction of a space structure in a laboratory environment.

4.6 Continuation of NSTP partnerships and collaborations

By encouraging the formation of new partnerships, and strengthening these through grant-supported projects, it is hoped that the NSTP will also support strategic partnerships and collaborations within the UK space sector to continue *beyond* the life of the individual NSTP project.

NSTP2 lead organisations were asked through the survey whether they had worked with any of their NSTP **partners again since the end of their project** (or intended to do so in the future). Nearly all (93% of those with NSTP partners) replied that they had worked (or would work) again with at least one of their partners, and that overall they had / would collaborate with 91% of their partners again.

This positive result is even more impressive when we recall that most of the partner organisations (70%) were said to have been *new* collaborators at the time of the NSTP project. This means that across the whole NSTP2 portfolio it is likely that **40-50 newly-established partnerships are continuing**, beyond the life of the programme (in addition to tens of already pre-established partnerships that are also continuing, but further strengthened by the experience of the NSTP project).

For some participants, the continuation of NSTP partnerships is currently just an ambition: *"One important benefit is that we were introduced to a supply chain that we can use again in the future"*. However, there are many examples of follow-on work that is already being undertaken between newly-established or newly-strengthened NSTP partnerships: *"The project provided a good opportunity to collaborate with the University, where we are now supporting a PhD student to continue the next phase of the project"; "A long-term benefit has been the development of our relationship with an industrial partner. We have gone on to work on other projects together, and are currently applying for an NSTP and an ESA grant together [to further develop GEI-funded technology]."*

Project leads were also asked whether they thought NSTP2 participation had, more generally, increased the **attractiveness of their organisation as a space R&D partner**. Nearly all organisations (98%) felt that it had (including 59% 'to a large extent'), while the one other organisation said that, while they had not seen this benefit yet, they expected to in the future: *"The NSTP project has grown the capacity in our organisation to take a leading role in future space R&D"*. The results for non-lead organisations was nearly as positive, with 85% reporting that participation had increased their attractiveness.

4.7 Increased visibility and reputation of UK capabilities

With a core intention of the NSTP being to develop UK capabilities for further investment, leads were asked whether the programme had increased the **visibility and reputation of their organisation** in the space sector. Nearly all leads (93%) believed that it had done so already (44% 'to a large extent') and a further 5% expected that this would be seen in time (see examples below). Only one of the leads felt that the programme had made little difference to their visibility or reputation in the sector (they also reported that "*the research did not work and was not continued*"). Similarly, 83% of other partner organisations reported increased visibility and reputation of their organisation from the NSTP2 project.

"As a researcher that arrived in the UK four years ago, the project gave me the chance to connect with the main space groups in the UK, and get visibility"

"The project has allowed us to demonstrate that we are active in the field"

"One significant benefit has been to expand the visibility of the team in space. This can be evidenced by an invitation to submit a conference paper to Acta Astronautica, being invited to give a course at ESA-ESTEC on robust control (including results from NSTP2) and being contacted by DLR in Germany to work with them in different space-related projects."

Most project leads and partners also reported positively on the impact that NSTP2 participation had had in terms of their organisation's future prospects in the space market. For example, by:

- Increasing their attractiveness to institutional funders (reported by 95% of leads, 69% of partners)
- Increasing the likelihood that they will secure contracts in the space sector (90%, 69%)
- Increasing the likelihood that they can expand their presence in space markets (93%, 55%)

This is either better positioning these organisations to secure future funding (e.g. *"The project put us in a position to apply for a full mission and showed that the country had the expertise and experience to create a space station"*), or in some cases has already led to further awards and contracts (e.g. *"We won an ESA award for the management system produced through the project"*).

4.8 Projects de-risked for further investment

As well as awareness and visibility for the UK space sector and its technologies, the NSTP also seeks to support the development and demonstration of project ideas to the point at which they are de-risked for further investment elsewhere, whether that be other grants, internal funding, or institutional or commercial contracts. Space is often a risky, long-term venture that dissuades investors from financing early-stage technologies, and the NSTP seeks to address this critical funding gap for lower TRL projects.

Most leads (80%) reported that their **project had been de-risked** to some degree through their NSTP projects (in nearly all cases 'to a small extent'). In addition, two-thirds of leads (63%) reported more specifically that NSTP had resulted in a reduction in the cost of their project idea or technology, while three quarters (77%) claimed that it had reduced the time to market. To take some specific examples:

- An SME manufacturer used an NSTP2 Fast Track grant to demonstrate the feasibility of using a lightweight metal matrix composite as the basis for a propellant tank for nano-satellites. The novel material and manufacturing process (diffusion bonding) was able to meet the design parameters where a conventional tank would have been very much more costly to produce and probably too small. The NSTP grant de-risked the development work; it was a sufficient encouragement to cause a prime to agree to support the project where they would otherwise have insisted upon a lower-risk, conventional solution supplied by a larger, established manufacturer of titanium propellant tanks.
- One of the large Flagship grants enabled an aerospace manufacturer to move forward with the in-flight demonstration of a new 50kg class of small satellite along with the showcasing of a novel multi-spectral gas imaging technology designed to map concentrations of NO2.

The Flagship built on previous NSTP awards (for the proof of concept of the imaging technology) and ESA feasibility studies (for the low-cost, high resolution, high revisit satellite). The costs of taking the next step – in-orbit demonstration – are too high for the company to pursue independently and it is waiting for an opportunity to secure follow-on funding; the company estimates it will cost a further €50M to complete the development cycle and as much again to build and fly the 24 satellites needed to provide sufficient coverage / revisits for a global air quality monitoring system. The company has done preliminary analyses of the market and foresees demand among local authorities and transport, logistics and insurance firms - suggesting it could reach break-even within a few years.

- A Fast Track project was successfully used to develop and demonstrate a compact and highly efficient 1Gbps x-band transmitter. The collaboration (with an electronics company) developed a Gallium Nitride (GaN) integrated circuit which delivered double the data rate of its current transmitter (500 Mbps) with improved power consumption. They have not yet reached the efficiency they are looking for (to provide the necessary service life), but are continuing to work on the power amplifier. The company is already offering the new transmitter on satellites to customers, and it is also continuing to collaborate with the electronics company on a new Ka-band antenna

Leads were also asked about the impact of the programme on the **visibility and awareness of their specific NSTP2 project** idea or technology. Again, the results were very positive, with 93% responding positively (although here only 20% said that visibility / awareness had improved 'to a large extent'). Over half of project leads (51%) also reported that specific technologies or concepts were demonstrated through their NSTP2 project. For example: *"The NSTP project was the direct basis for a current proposal to the GSTP. ESA were already aware of the NSTP project and had provided positive feedback, suggesting that an application was almost certain to be successful"; "Because of a journal paper arising from the project, the work has been recognised by key European experts in ESA"; "The project successfully demonstrated that you can use this technology to identify small item methane emissions from the oil and gas sector. It also showed that there is a big market for this".*

4.9 Generation of additional contracts and revenue

Many of the NSTP2 projects are only now concluding. In addition, the programme does not usually provide support beyond TRL5 (except for Flagships), which means that demonstration and flight qualification need to be addressed through other routes. However, despite these points, two of the 41 project leads consulted (5% of this sample) reported that they are already **generating additional (commercial) revenue as a result of developments supported through their NSTP project**:

- One company has raised the TRL of their technology through the NSTP to the point that it has been contracted for inclusion on a lunar mission. The technology is also being used in Formula 1, generating additional commercial income. This mix ("space to race") means that improvements in the Formula 1 product (where the investment is in the software) cross-fertilises with ongoing work in space (where the focus has been more on technology development). The NSTP grants have already generated over £1M in new contracts, and the company is very confident of many more opportunities in the near future (e.g. they have just pitched to a US aerospace company). The technology is applicable to a range of space-based and terrestrial applications; "*basically, anywhere where there is a need for high performance, low mass and ruggedness in 3D imaging.*"

- The NSTP has provided another company with sufficient experience of propellant systems to secure a £293K collaborative R&D award from Innovate UK to co-fund the development of a novel High Test Peroxide (HTP) propulsion system. The new system is an environmentally friendly and cost effective "green" replacement for hydrazine propellants, which are commonly used in satellites.

Nearly all other leads (another 90%) believed that their **project may lead to additional revenue in the future**, including nearly half (47%) who believe there is a 'high' or 'very high' probability of this (others gave a medium or low probability). In the two remaining cases, where there was thought to be no likelihood of developments supported through NSTP2 leading to further revenue, the relevant project leads reported that this was due (respectively) to their project being 'a very academic study' or because 'the research didn't work and was discontinued'. The widespread likelihood of projects generating income is an impressive outcome for the programme, when one considers that a certain level of failure is expected when projects are (by design) exploring unproven technologies and testing feasibility.

Some respondents also provided suggestions as to the likely source of future revenue. While these are often just speculative, it is interesting to see the range of routes that are foreseen. For example:

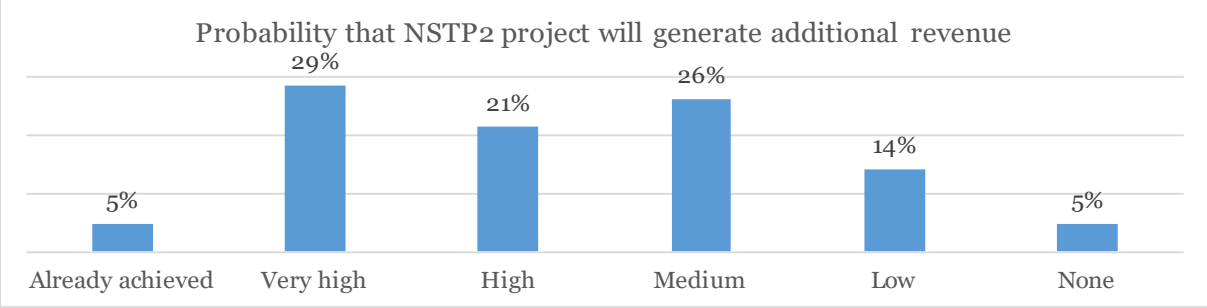
- Commercial revenue
- Terrestrial applications
- Selling data generated
- Academic grants
- Licensing
- EPSRC funding
- ESA funding
- Further NSTP funding to get project to TRL 5
- Customers paying to use the service
- Interested companies outside of the space sector

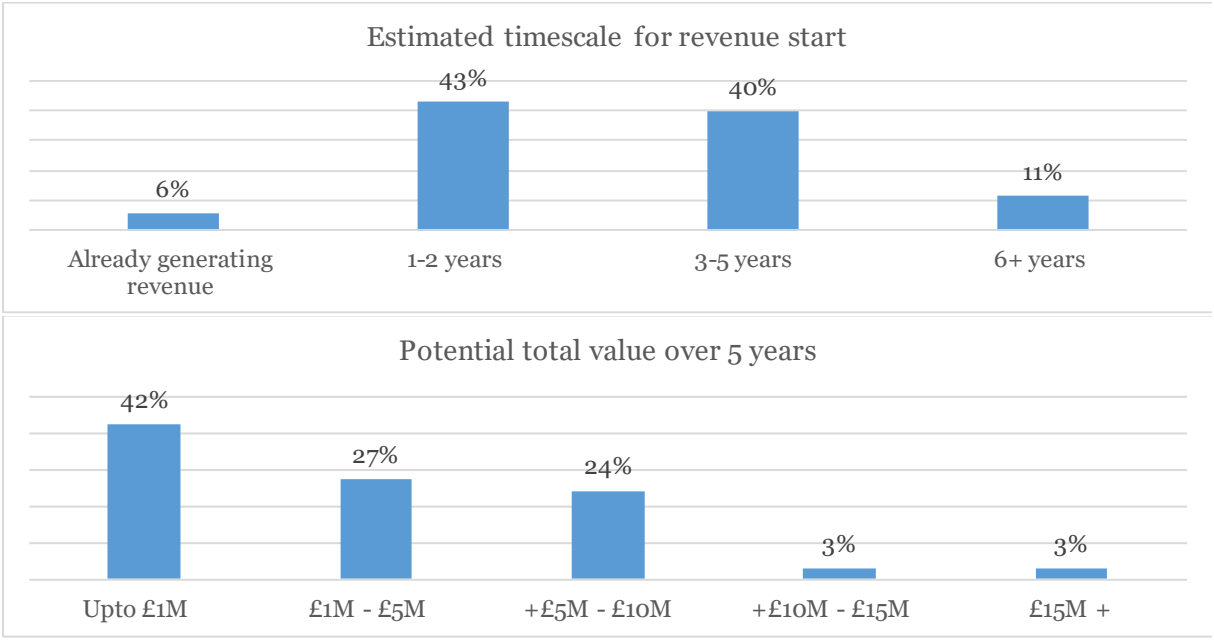
Leaving aside the two projects already generating revenue, most other project leads expected the additional revenue foreseen to **start being generated within the next 1-5 years**. Specifically, 39% believed revenue would start in 1 or 2 years, 42% predicted 3-5 years, and 12% suggested it might take 6 or more years before additional revenue linked to their project started to be realised. Such predictions seem realistic, based on the fact that 3 of the 9 NSTP1 leads (33%) also surveyed reported that their project was now generating additional revenue, 2-3 years after the end of that round of projects.

Leads also estimated the potential value of **predicted future revenue**, for a five year-period from its commencement. Just under half (45%) suggested the figure would be less than £1M, while a further 49% estimated that it would be between £1M and £10M. The remaining 6% predicted higher figures.

In the next section, these three assessments (likelihood, timescale and value) are combined to estimate the future revenue generation of the NSTP2 project portfolio.

Figure 6 Likelihood, timescale and value of additional contracts and revenue generated from NSTP2 project





Survey of NSTP2 project leads (n=41, 33 and 31)

The following quotes and examples show a selection of cases to exemplify the types of revenue generation that is being seen and is expected going forwards.

Examples of NSTP2 projects already generating additional revenue

- A university and company have gone on to use the software developed through an NSTP2 Pathfinder for an ESA grant project. The software has also been licenced for £50k/yr.
- *"So far, the only income that can be attributed is a £6k STFC grant for a follow-up project. However, we have 2 patents pending on the new technology and this offers a route to licencing and commercialisation in the future."*
- *"The project has led to involvement in at least two other ESA projects (worth £400k, in partnership with another UK firm). It is also likely to lead to work with ESA and NASA"*
- *"We have 25 people working on developing this technology through various projects, which can all be attributed to the initial NSTP. These are funded through EPSRC, SSTL and NSTP grants"*
- *"The Fast Track project produced a routing switch which is now being commercialised by our industrial partner. The company also won two ESA projects related to this work and (with the university) was awarded a grant for an H2020 project"*

Examples of NSTP2 projects serving as a basis for further (outstanding) grant applications

- A PhD student is now continuing the work from an NSTP2 GEI project "his post would probably not exist if we hadn't been able to prove the concept… We have also applied for EPSRC funding to develop the technology [electrospray thrusters] for medical purposes"
- An NSTP project was the direct basis for a current proposal to the ESA GSTP programme. "ESA were already aware of the NSTP project and had provided positive feedback – suggesting to us that an application to the GSTP was almost certain to be successful"

Examples of NSTP2 projects expected to lead to commercial income streams (in future)

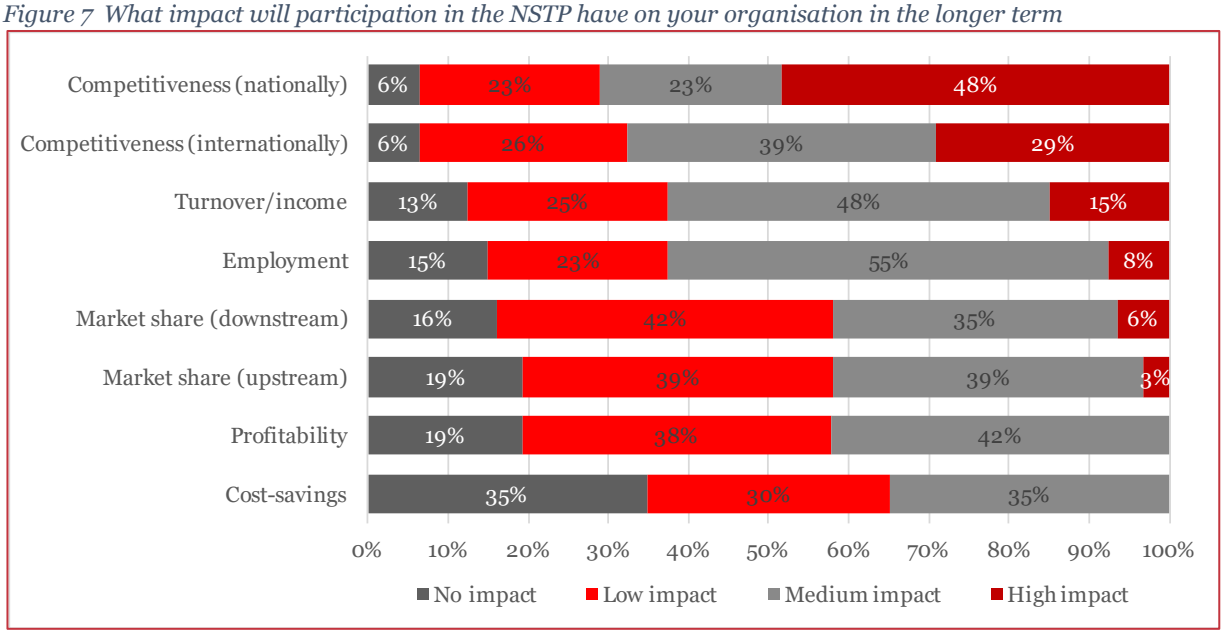
- An NSTP2 Flagship project is expected to lead to commercial contracts worth £5-£10M over the next 5 years. According to the company involved *"the technology could also be easily adapted to track other objects, e.g. airplanes, increasing its potential value"*
- The lead for a Fast Track project explained that there were two potential contracts directly resulting from the outcomes of their NSTP2 project: *"The first was a contribution to a common EC proposal, but this was lost despite a very high score (94/100), owing to the very competitive framework for such calls. The second is a UK contribution to a future implementation phase of the ESA Phobos Sample Return study (Phase B1 and beyond). This remains a future possible opportunity, but is subject to an ESA decision as to whether to pursue this programme. However, other ESA programmes could also benefit from the technology development addressed in the NSTP2 project."*

Leads were also asked what the additional contracts might mean in terms of **additional jobs created or jobs safeguarded** within their organisation. Nearly half of respondents (47%) indicated that at least 1 FTE job would be created / safeguarded as a result of subsequent contracts, with these individuals indicating a total of 79 jobs (4 each on average)[14].

4.10 Longer term impacts of participation in NSTP2

To conclude, NSTP2 lead organisations were asked about the **longer-term implications** of their participation and what impact this would have on various aspects of their organisation. As can be seen below, a majority (65%+) suggested there would be some impact in all eight of the areas suggested. In most cases, this impact would 'low' to 'medium', but in a few areas, there were a sizeable proportion of organisations that predicted 'high impact'. In particular, on the organisations' competitiveness – both nationally and internationally – and to a lesser extent their turnover, employment and market share.

Figure 7 What impact will participation in the NSTP have on your organisation in the longer term



Survey of NSTP2 project leads (n= 23-40)

[14] This excludes one outlier (predicting 4,000 jobs safeguarded in the longer term). All others lead predicted 0-5 jobs safeguarded.

5 Value for money

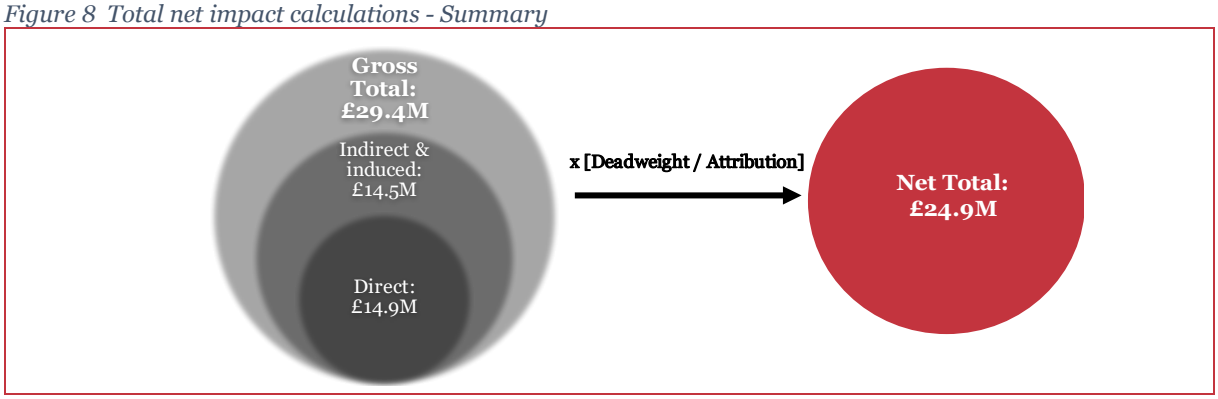
5.1 Total net impact

We estimate a **total *net* impact of £24.9M from NSTP2,** based on the sample of (33) survey respondents. This represents an absolute minimum for the programme, as we would expect the actual scale of impact to be considerably higher if the full portfolio of NSTP2 projects were considered[15].

The calculation of net impact is explained in full within Appendix A.3 and follows the guidelines set out within the HM Treasury Green Book. It considers the total value of contracts (commercial and non-commercial) that have emerged (or are expected to emerge) due to participation in the programme, as well as the timeline for the start of this revenue and the probability that it will happen at all. It also takes account of the knock-on effect that these contracts have on the wider economy, in terms of (i) the activity supported across the supply chains of the NSTP2 participants, as well as (ii) the additional economic activity supported by people directly employed by NSTP2 participants and their suppliers (who spend their wages on goods and services in the wider economy). Finally, our estimates also account for factors of deadweight, leakage and displacement, which are detailed further in the methodological annex.

The figure below summarises our estimates, and the progression from direct impacts to total net impact.

Figure 8 Total net impact calculations - Summary



Source: Technopolis (2018). Based on 33 respondents.

5.2 Return on investment

Based on these estimates of impact and the public investment (grants) made by UKSA (£3.1M) in this sample of projects, we estimate that NSTP2, at a minimum, will have a return on investment of 7.0. This means that **every £1 invested will generate a net impact of £7 over a 5-year period** (2017-21). Coincidentally, this RoI is the same as that estimated in the recent evaluation of UK participation in the ESA General Scientific Technology Programme (GSTP), providing extra confidence in our results.

In addition, the investments made by the UKSA have also **leveraged funding** across organisations / participations, which in some cases goes beyond the legal requirements because the organisations concerned (especially companies) are prepared to top up their

[15] A simple linear extrapolation from the 33 respondents to the full portfolio of 120 NSTP2 projects would suggest that the programme will generate a total net impact of £89.1M. See Appendix A.3.5 for further discussion of this extrapolation.

original commitments to drive the project to a successful conclusion. This has been the case in one of the Flagship projects for instance, where the co-funding from industrial partner organisations has increased from £0.8.M to £1.3M during the project. This was mainly because the industrial partners foresaw a substantial revenue stream of approximately £5-£10M, and therefore saw a clear business case to keep on investing in the project.

Based on survey responses regarding funding leverage (20 responses) we estimate that a budget of £2.6M (NSTP grants going to these survey respondents) leads to a co-funding of £1.4M. As such, in these cases, each £1 of (public) funding leads to an additional £0.54 of investment from participants.

6 Process evaluation

This section concerns the processes and activities associated with programme design and delivery. While not a core aim, the study was tasked with assessing various aspects of implementation and the implications of these (i.e. the extent to which they act as drivers or barriers) for programme effectiveness (i.e. benefits and impacts realised) and efficiency (i.e. the extent to which it represents value for money).

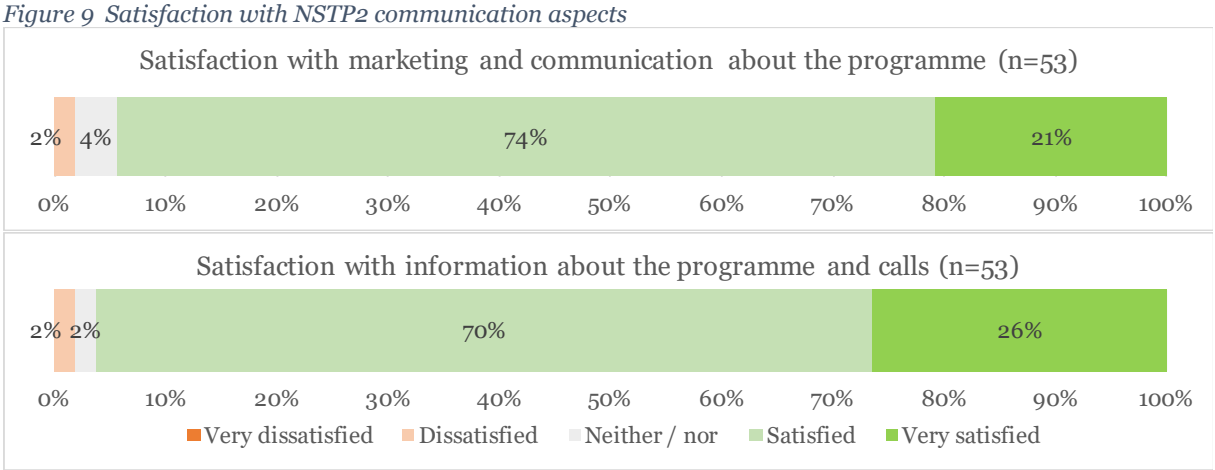
The telephone survey of project leads and online survey of project partners asked participants to rate their satisfaction with various aspects of programme administration, delivery and implementation, before inviting comments, suggestions or recommendations relating to possible areas for improvement. These aspects were further discussed through follow-up interviews with a selection of participating organisations and with the programme management teams in both UKSA and CEOI-ST.

The section is structured around common themes that emerged through the consultations, while also taking account of the areas for consideration originally suggested in the study terms of reference.

6.1 Programme communication

Surveys of NSTP2 participants showed widespread satisfaction with marketing and communication about the programme, and with information provided on grants and calls. Over 90% reported that they were either satisfied or very satisfied with both of these aspects.

Figure 9 Satisfaction with NSTP2 communication aspects



Surveys of NSTP2 leads and partners

While the awareness of the programme amongst past participants is good, several members of the NSTP management teams (UKSA and CEOI-ST) felt that more could / should be done in

terms of **external engagement and communication about the programme**. For instance, to encourage new entrants to the programme and an improved geographical spread, or to target certain sectors that UKSA is keen to support. Suggestions put forward included holding workshops across different parts of the UK, or working with Local Enterprise Partnerships to promote the programme through their network.

Amongst project participants there were regular requests for improved **communication of forward-plans** for the NSTP. Specifically, they wanted greater certainty as to whether / when future programme calls would be released, what these calls would cover, the likely budget available, and where the announcement would be made. In some instances, this was because individual organisations had 'missed' previous calls. But more generally, improved knowledge about timelines would better allow for preparation (considering potential ideas / projects of relevance, finding partners and co-funding, etc.).

Related to this, several participants also indicated a desire to have more information that would enable them to understand what their chances were of success (i.e. Does their project idea align with what the programme wants to fund? Are success rates sufficiently high? Is there sufficient programme budget?), such that they can make an informed decision about whether and what to propose.

There were also calls for greater dissemination on **past projects and their achievements**, be that through brochures, an improved online presence, or marketing events. Such activities, they believe, could help to advertise the programme to potential future applicants, disseminate knowledge and information from projects to the wider UK space community, are share possible future development opportunities. They would also show to others (e.g. ESA) that "the UK is busy, it is investing, and that UK capabilities are growing" - helping to both build reputation in general, as well as highlight specific opportunities to potential funders and investors.

Already, projects are expected to produce a final report and executive summary that are suitable for publication. NSTP call documentation suggests the intention was to upload at least the executive summaries of these reports to the UKSA website, but we are not aware that this has been done. There is currently a list of current and past projects (title and lead organisation) provided online[16] - although this is not complete and is a little out of date. In addition, an NSTP brochure is available to download[17] that contains case studies of five past projects. There is presumably a wealth of material that UKSA could draw on (subject to commerciality restrictions) to expand this available publicity.

Project presentation days have also been held, in which those funded through the NSTP present a summary of their work and achievements. NSTP participants highlighted these conferences as good opportunity for networking between different participant organisations and to identify possible new partners and collaborators for the future. There was a common appeal from participants to ensure that more such events took place in the future – and that these be used both to support sharing and networking within the UK space community, and also to promote the programme and UK capabilities more widely. A fixed annual event might help establish this forum both nationally and internationally.

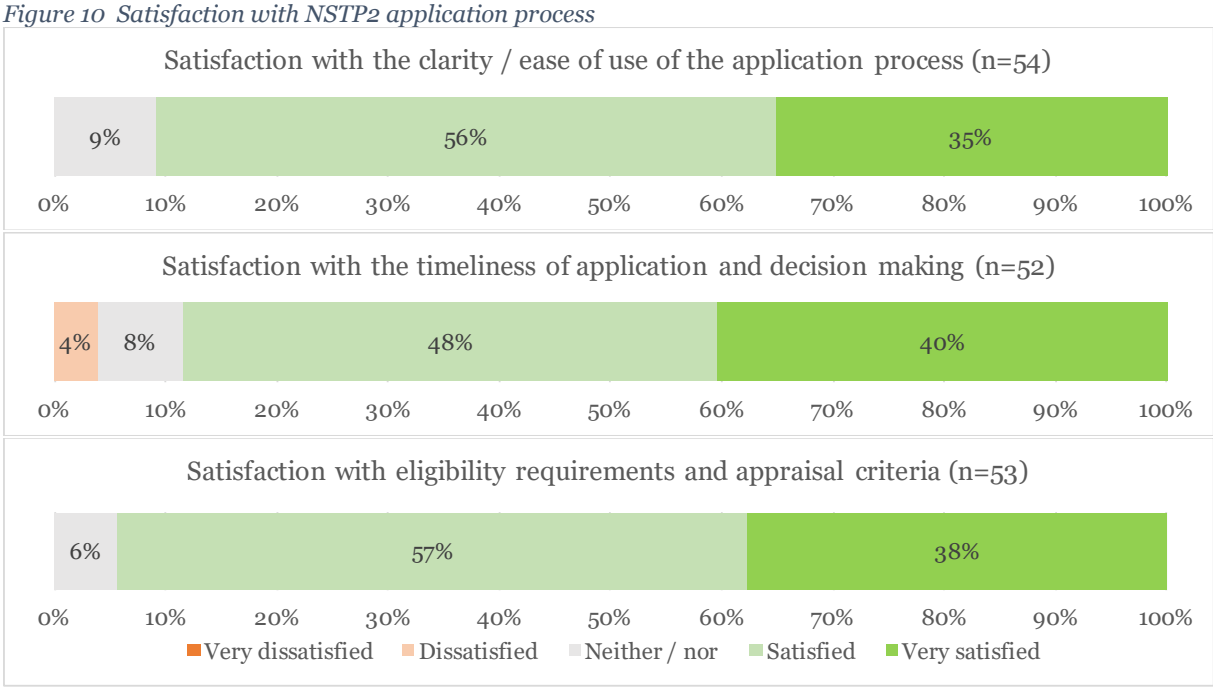
[16] https://www.gov.uk/guidance/apply-for-funding-through-the-national-space-technology-programme

[17] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/661775/NSTP_Final.pdf

6.2 The application process

Programme participants also reported widespread satisfaction in relation to the NSTP application process. This includes the clarity and ease of the application process, the timeliness of the application and decision making process, and the eligibility requirements and appraisal criteria employed.

Figure 10 Satisfaction with NSTP2 application process



Surveys of NSTP2 leads and partners

The NSTP management teams outlined various **improvements** that have been made to the application process over time. This includes adjustments to the application forms that are felt to have increased the quality of application, as well as improve the ability to assess and compare between these applications. The application process has also been made electronic, and workshops and seminars have been run to increase understanding of programme requirements and the application process.

Participants were generally positive about the processes, forms and templates in place, reporting that they were relatively simple to use, easy to understand and required minimal cost and effort to complete. For instance: *"The requirements for the GEI award are minimal. I probably only spent a few days putting together the proposal."*. Where requirements were more demanding, this was also recognised as being appropriate: *"There was quite a lot work at the pre-application stage to scope out terms with their partner and agree how they would split the IP arising from tech developed. However, this is something we would have had to have done at some stage in the project anyway. And it was helpful that the NSTP application form required the IP agreement to be in place at the outset, because this stopped any disagreements arising once the project progressed"*

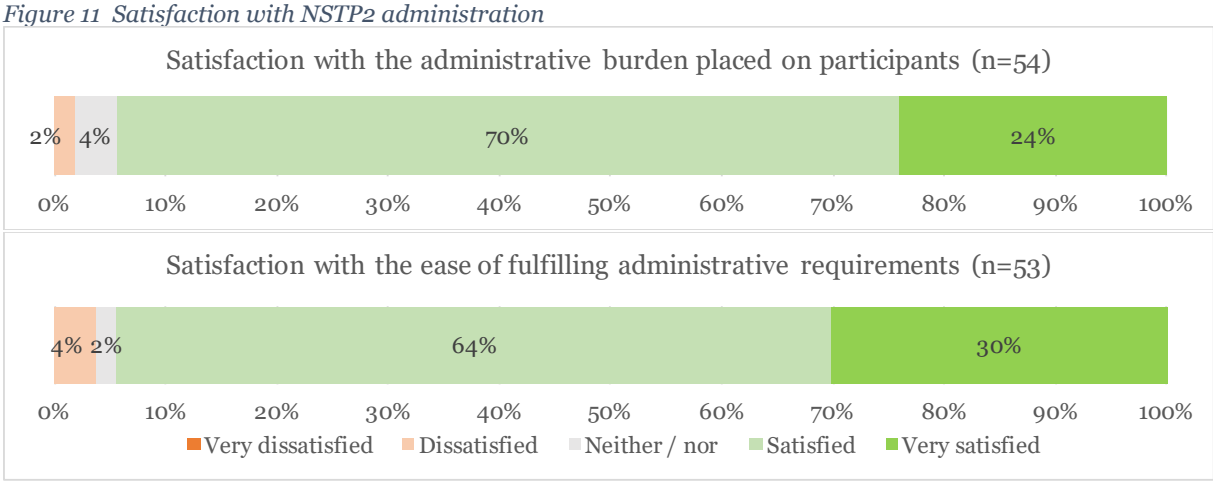
The one aspect of the application process where participants did suggest improvements related to the (in)**frequency of calls**. NSTP funding was generally perceived as being very 'stop-start', with little clarity over whether, when or what calls would be issued in future. This can create uncertainty and a lack of continuity: *"The gaps between the phases of the programme create problems for companies. We cannot just keep a team in place in the hope that funding will be available soon for the next stage"*

Our discussions with UKSA highlight that this issue is well understood – specifically that it can cause uncertainty amongst both industrial and academic organisations, and may result in a loss of expertise in the UK space sector (e.g. with scientists and engineers taking up jobs in other sectors). However, budgetary issues may limit the extent to which calls could become more regular or consistent.

6.3 Programme administration

The vast majority of participants reported being satisfied with the level of administrative burden placed on them, as well as the ease with which these administrative requirements could be fulfilled.

Figure 11 Satisfaction with NSTP2 administration



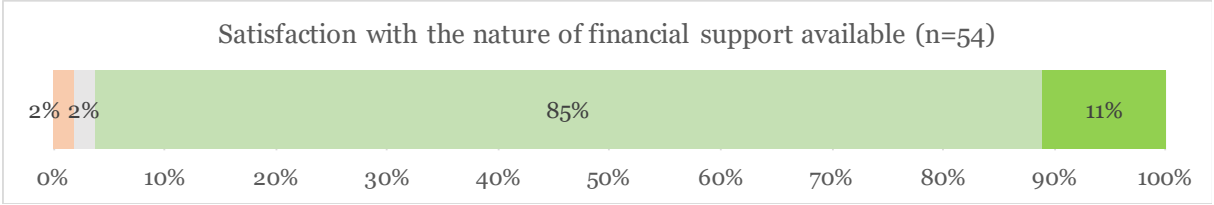
Surveys of NSTP2 leads and partners

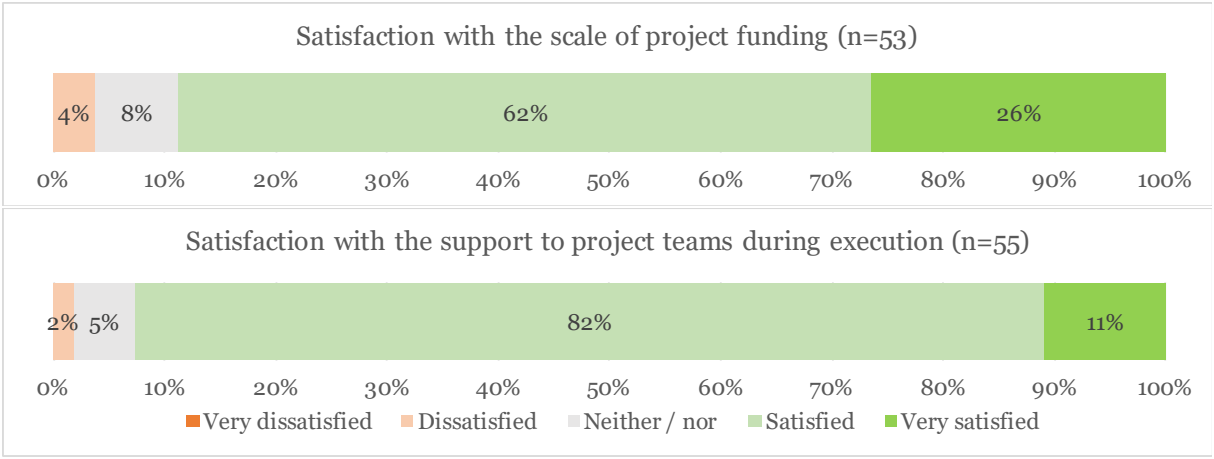
Management staff explained that the programme had sought to set differing levels requirements to reflect the varying timescales, values and complexity of projects, trying not to overly burden participants unnecessarily. Staff also play an active role in monitoring progress and assessing risks to delivery, and aim to identify what support may be needed to keep projects on track. All the feedback we received from participants would suggest that the programme team are doing a good job, and that the scale or difficulty of administrative programme requirements is not a source of concern for those involved in projects.

6.4 Support to beneficiaries

Feedback from project leads and partners suggest that nearly all of those participating in NSTP2 were satisfied with the scale and nature of funding being provided and with the other (non-financial) support provided to teams during the execution of projects.

Figure 12 Satisfaction financial (and other) support provided through NSTP2





Surveys of NSTP2 leads and partners

However, despite this overall assessment, a number of those surveyed and interviewed did suggest that there may be benefit to increasing the **flexibility of grant awards in terms of the budget** (and timescale) restrictions applied to the different types of funding. The limits set were seen as overly restrictive, and did not allow for a range of circumstances that may arise. For instance, individuals pointed to the often-considerable manufacturing costs required for some types of projects (which left little grant money remaining for research and development work) or to the generally higher costs of bringing on board private sector partners within a consortium. Others pointed to the fact that some projects required longer to be undertaken properly, or that there were inevitably sometimes delays that it was difficult to accommodate within the relatively ambitious timescales set in place for some grants.

These concerns mainly related to the 'middle' two grants in the tiered system (Pathfinders and Fast Track), which are intended to cover a much wider range of activities between a £10K mini-study and a £1M Flagship project, but aren't necessarily set up to fully cover this spectrum. Some commentators suggested greater flexibility was required at the borders of the current grant options, other suggested additional tiers, while others still suggested a single grant type should be available for middle-tier projects, ranging from £20K to £500K and from 6 – 18 months.

Several participants and members of the management team also mentioned the total volume of funding available to the NSTP. There is clearly high demand for grants, so the programme could be supporting other good projects if sufficient funds were available. However, at present a project may have completed a GEI successfully and be expecting to progress to a Pathfinder the following year. But with limited overall funding available for the programme, there is not always the opportunity for all deserving cases to progress up the NSTP ladder. There may well be a bottleneck of good ideas that have shown feasibility and potential, but where there is insufficient money available to move forward. More generally, several participants highlighted that you need a scale and concentration of funding (on a project, in an area), to ensure real progress in building capacity and capability, and driving forward R&D to sufficient TRL levels. This is easier to achieve with a larger and more sustained programme of funding.

On the ongoing **support during projects**, respondents were largely positive and, where they had experience, pointed to improvements that had been made as the programme had developed. Some clearly welcomed the very hands-on "human" contact from UKSA staff: *"We benefited greatly from UKSA staff critiquing the project at various stages. There was good feedback from the team"*

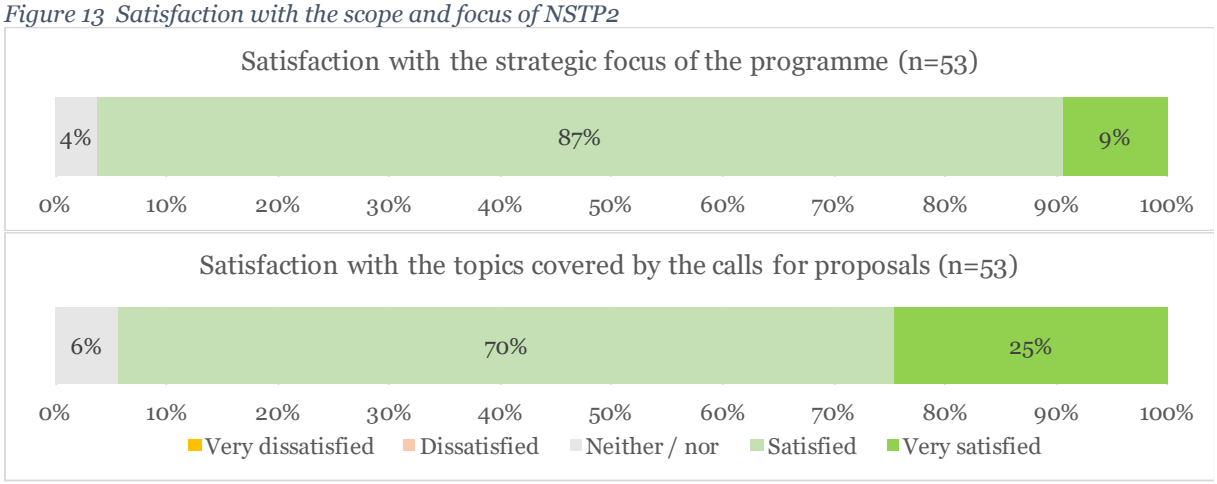
There were some concerns raised though that management staff are a little overwhelmed (too many projects to manage and monitor with the resource available). This would appear to be something that UKSA would recognise, as members of the programme management team highlighted that one or two more individuals could significantly increase the volume of projects that they could support and manage.

Some projects don't deliver as hoped – but for valid scientific reasons. Others underperform because of a lack of prioritisation of the project within the organisation concerned, because of delays or failure to deliver by a third party, or because of a lack of capacity to deliver within the organisation. UKSA have placed more emphasis on monitoring project progress, risks and timescales over time (including by moving management of these processes in-house), and the team are clearly considering how best to balance the limited resources available across the different types and sizes of grant and project.

6.5 Scope and focus of the programme

The surveys of project leads and partners also asked more broadly about levels of satisfaction with the scope and focus of the NSTP2 programme and calls. None of the respondents indicated any dissatisfaction in these regards. Indeed, over 90% claimed to be satisfied or very satisfied with both the strategic focus of the programme and with the topics covered by the calls (which is essentially limited to a general requirement that projects align with Technology Roadmap Themes).

Figure 13 Satisfaction with the scope and focus of NSTP2



Surveys of NSTP2 leads and partners

The programme was **designed to be 'open'** in terms of the types of ideas, technologies and organisations it is willing to support, and this is clearly recognised and supported by participants. This was regarded as a positive approach because "it didn't stifle innovation" or seek to "pre-determine or second-guess what technologies should be supported", therefore allowing new and different ideas to come forward for consideration and peer review (including spin-ins to the space sector).

However, UKSA are also mindful of the need for the programme to maintain relevance to wider strategies and priorities (e.g. priority sectors such as battery storage and AI, highlighted in the new Industrial Strategy published in November 2017; or technologies that are important to future ESA missions), not least to help make the case for continued public investment. Despite

the openness of the programme, the agency is still able to provide some degree of guidance within the text of calls to encourage proposals to come forward in particular areas.

There was also some (limited) support amongst participants for a slightly more targeted approach for the programme, mainly driven by a desire not to 'waste time' on proposing projects that were not of interest to UKSA, but also a broader sense that making real progress with programme goals may require a concerted effort (through the grant funding and by other means) to push hard at particular areas. For example, one project lead commented that "*"The overall goal of the NSTP programme is clear, in that it is to support the UK's aim to develop the space technology and skills necessary to grow the UK economy. What is less clear is what it is going to focus on to achieve this and how it is going to encourage UK organisations to focus their energies on these goals".*

The NSTP sits within a complex **landscape of funding available** for space technology development, and there was some concern within NSTP management teams that it could be confusing for potential participants to understand what the NSTP offers and whether it is appropriate. One member of the management team suggested that a piece of work could usefully be done to better map the funding landscape and the position of the NSTP within this. We would agree that there does appear to be a bit of confusion in the market place about the programme and where it fits in with the wider UKSA activities (e.g. fit with CREST) and those of Innovate UK. It would therefore be helpful to have a map of the wider funding landscape, which would locate the NSTP and explain how it is distinct and where / how it draws on and feeds into other schemes

However, amongst current participants, the NSTP is generally seen as having a **clear (and unique) role** within wider funding landscape, offering distinct features and addressing needs that are not being met elsewhere. For instance:

- Supporting entry level projects to get initial ideas off ground (small-scale initial funding for e.g. exploratory studies and feasibility projects)
- Being open to new and "risky" ideas and technologies. that would not be funded elsewhere
- Supporting the progression of projects up lower TRLs (including through multiple stages of award), until they are ready (de-risked and demonstrated) for other funders
- Encouraging collaboration between industry and academia, enabling the creation of new synergies and partnerships that go beyond the core aims of the project.

A number of participants discussed alternative funding options available to them and why these were not appropriate or feasible. For instance:

> *"We had looked at Innovate UK funding, but the PV requirements were too harsh (we don't have the cash or product at this stage in our development). By comparison, H2020 offers 100% funding, but there are other big barriers, such as the complexity of application and the for a European consortium. The situation within the NSTP - the rate of funding and the ease of access - is much better"*

> *"It is very difficult to make the financial case for early stage projects that ESA or other private sector investors would require. UKSA understand that exploratory projects have value, even if not immediate direct commercial value."*

"We would not have been able to apply to the ESA consortium without evidence that the technology worked first. We needed NSTP funding for development work"

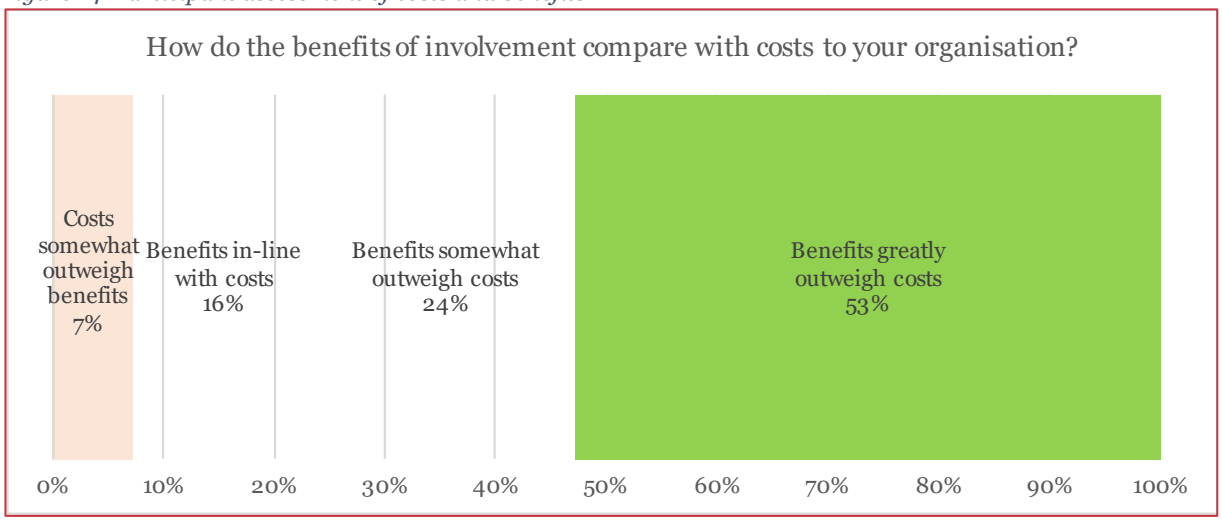
One regularly mentioned barrier to NSTP-supported projects' achieving their ultimate objectives (e.g. for the technology to be adopted by a major space mission), is that ESA or NASA will want evidence that the technology has been tried and tested in space first. To do this, it has to be adopted on other pilot rocket launches. The UK currently lacks its own national rocket launch programme. Project leads are therefore dependent on getting their tech adopted on rocket launches led by other countries, including India, USA and Russia. However, their programmes vary in frequency of launches and relevance to UK technologies, so the opportunities for uptake, testing and demonstration are limited.

Therefore, to maximise the opportunities for testing technology developed via NSTP projects, and their subsequent chance of successful uptake on future space missions, one wider recommendation is for the UK to invest in developing its own space port with a planned programme of rocket and satellite launches. This would grow the UK space sector capabilities and enhance the overall impacts of UKSA programmes: *"We are very interested in demonstration flights. Anything that can help prove our products work is vital. NSTP does this to an extent, but to take this further, a demonstration would be great"*

6.6 Participant assessment of the costs and benefits to their organisation

From the perspective of participants, the NSTP offers clear value for money. More than three-quarters (77%) of the leads and partners consulted through the study reported that the **benefits of involvement in the programme outweighed the costs** to their organisations. In fact, for most organisations the benefits '*greatly* outweigh' the costs. This compares to just 7% that thought that the costs to their organisation somewhat outweighed the benefits. Lead organisations tended to report a slightly better benefit-cost ratio, compared to other partner organisations, which is perhaps not unexpected given (usually) their central ownership over the project idea or technology.

Figure 14 Participant assessment of costs and benefits



Surveys of NSTP2 leads (n=41) and partners (n=14)

The remaining 16% of respondents thought costs and benefits were broadly aligned. Some of the organisations responding as such provided some further explanation of their assessment:

> *"We have benefited hugely from the project, but our product is in its earliest development stages and will therefore not be cost effective for several years yet"*
>
> *"If our partners move to production, then we will benefit more"*
>
> *"We were unsuccessful with a subsequent bid for further development".*
>
> *"We focus on the research. Commercialisation of this will be done through the industrial partner."*

7 Conclusions

This final section highlights key findings and conclusions from the evaluation, drawing on the various evidence presented in the preceding chapters. It ends with several suggestions for areas that the UKSA might consider further in order to improve the programme moving forwards.

7.1 On the impact of the NSTP

Most NSTP2 projects had only recently concluded (or were still ongoing) at the time of this evaluation, while some of the core intentions of the programme (e.g. supporting entry to / expansion within institutional and commercial space markets) are only expected to be realised in the months and years after project conclusion. Therefore, **findings are only preliminary at this stage**.

As such, the achievements realised by NSTP2 projects and participants to-date focus predominantly on **in-project benefits and immediate outcomes.** For example, the study has found that NSTP2 funding has created large numbers of new and strengthened UK partnerships; led to widespread improvements in capabilities; and raised the TRL level of many tens of project ideas and technologies.

Looking beyond the grant period, participants generally have **positive expectations as to longer-term and wider implications** of their programme participation. For instance:

- Most participants believe their NSTP2 project has increased the visibility and reputation of their organisation within the space sector (both to potential partners and funders)
- Most also believe it has improved their prospects within space markets, by increasing their attractiveness to funders and increasing the likelihood of securing contracts
- Most leads report their NSTP2 grant has de-risked their project for further investment, including in most cases a reduction in costs and time to market for their idea / technology
- Nearly all leads believe their NSTP2 project may generate additional revenue for their organisation (for most the probability is 'high' or 'very high'). This is a strongly positive outcome, given that a certain level of project failure is expected when exploring early stage ideas and technologies

There are already many **examples of partnerships continuing** beyond the NSTP2 project (including most of those *newly* established through the programme), as well as of **bids submitted for follow-on project grants** (e.g. to NSTP3, Innovate UK and ESA). In addition, there are already a few examples of **follow-on contracts and grants being awarded** – by UK and European funders.

7.2 On the programme's value for money

The probability, timing and scale of additional income that participants expect will result from NSTP2 participation have been used to calculate the economic impact of the programme.

Based on 33 respondents' estimates of £40.2M in (new) income over a five-year period, we have estimated a **total *net* impact of £25M** from these particular cases (having converted to gross value added, and taken account of indirect and induced impacts, as well as deadweight). This is an absolute minimum, and a simple linear extrapolation to the *full* project portfolio suggests a total net impact from NSTP2-supported developments closer to £90M.

Based on public investments made through UKSA grants, the **return on investment** to the NSTP2 is therefore estimated at **between 7:1 and 10:1** (based on survey response or extrapolate figures respectively). This is a very positive result and, incidentally, aligns with a recent estimate for UK participation in ESA's General Scientific Technology Programme (GSTP).

From the perspective of participants, the NSTP also offers clear **value for money**. More than three-quarters of the leads and partners consulted have reported that the benefits of involvement already outweigh the costs to these organisations, even before many of the longer-term impacts are realised.

7.3 On programme processes

Participants have reported **widespread satisfaction with delivery and implementation** of the NSTP, including in relation to programme communication, application processes, administrative requirements, funding and project support. All the feedback received from participants would suggest that the management team are doing a good job of delivering and implementing the NSTP, and that positive adjustments have been made to various aspects of the programme to improve it over time.

Nevertheless, several areas were highlighted that might benefit from further thought and improvement going forward. These included in particular the programme's online presence (e.g. the quality and quantity of information available), the range of grants offered (e.g. flexibility around timescales and grant sizes), and the communication of the NSTP's role, objectives and forward plans.

7.4 On the programme overall

Participants view the NSTP very positively and want it to continue and expand. There is a consistent and positive view of its thematic openness, its emphasis on a larger number of smaller grants, and its focus on addressing lower TRLs. The NSTP2 offer also addresses an important market failure, where even the largest space companies will focus sharply on their proprietary technology development needs and will rarely fund interesting concepts that sit outside their prescribed strategic technology roadmap.

Very few survey respondents believed their project would have gone ahead (at least in any kind of similar form) without NSTP2 funding. For example, the following quotes provide an indication of the range of feedback provided by participants on this 'counterfactual' question:

> *"The only alternative would be industrial funding, but it was too early stage (it would have been seen as too risky), and so the NSTP was the only feasible option"*
>
> *"It is difficult to include external partners like universities in projects when these are (fully) funded by our internal R&D budget, so the NSTP gives us the opportunity to engage with those organisations, which may not have happened otherwise"*
>
> *"It would have been harder to take forward, and would have been less ambitious, but I can't say the project would not have gone ahead in some form"*

> *"Some work would have been done, but not fully. NSTP funding enabled me to work 3-4 months specifically on a task, which has now fed into a ESA mission proposal"*

The programme is successfully creating a diverse and expanding pool of interesting ideas and technologies that are unlikely to have progressed otherwise. However, there is a lack of capacity within the current programme to fully capitalise on all of these opportunities (i.e. in addition to supporting the next round of 'new' projects). Without a larger budget (or even with one), there is a need to do more to support the community in taking forward promising projects by other means. In addition, there are substantial costs and risks associated with progressing novel technologies from mid-TRL validation (the point at which NSTP funding tends to stop) to higher TRL in-flight demonstration, and on to commercial sales. Many NSTP technologies have limited in-flight heritage and will, by definition, struggle to make a case for inclusion in e.g. ESA or NASA missions. There were therefore also calls from NSTP participants for UKSA to look for ways to improve opportunities for demonstration flights.

7.4.1 Areas for further consideration

While the study was not asked to provide recommendations, we believe there are a number of **areas that might be given further consideration**:

- UKSA should look for ways to improve the online presence of the NSTP, providing additional information (clear and easily navigable) on the objectives and key features of the programme, future funding opportunities and intentions, and past projects / achievements.
- UKSA should undertake (and publish) a mapping of the wider funding landscape, which would locate the NSTP and explain how it is distinct, as well as make explicit where and how it draws on and feeds into other schemes, both in the UK and elsewhere.
- UKSA should continue to hold regular programme-level events to allow projects to showcase their work to one another and to allow participants and prospective bidders to come together to learn from one another and discuss potential future collaborations and projects.
- UKSA should try to improve communication of forward-plans for NSTP funding, including when future calls will be released (ideally more regularised), what these will cover, and the likely budget. We understand that a new multi-annual funding arrangement should enable greater clarity here.
- UKSA should consider the suitability of the current range of grant types available. In particular participants have suggested there may be benefits to broadening the possible scale and timeline of individual awards, or introducing a new middle-tier option better takes account of the variable nature of potential projects (e.g. offering £20K to £500K for projects lasting between 6 and 18 months). Again, we understand that new programme funding arrangements should allow some greater flexibility, at least with regard to the start and end dates (and length) of individual grants.
- The UKSA might usefully perform an annual strategic review of its project portfolio, looking for the best means of moving promising ideas and technologies forward. This may be by encouraging follow-up NSTP bids or providing support / advice on taking forward projects by other means.
- Related to this, additional funding for definitional work might then also help to support UK projects in making successful applications to other funding sources.
- Also, specific follow-on grants might be considered, perhaps as a replacement for the current (open call) Flagship projects, which would allow the UKSA to further support the next stage in the development of a small selection of promising projects from within its past portfolio
- UKSA should look for ways to improve opportunities for demonstration flights for UK organisations. The new Space Industry Bill will enable the first commercial space launch from UK soil, but should also increase the capability to launch small satellites and scientific experiments. The Industrial Strategy also suggests that the UK Government will support this through a £50M programme.

Finally, it is worth reflecting on some of the challenges faced in evaluating the NSTP. We would suggest that **future monitoring and evaluation** efforts might be aided by:

- Obtaining the names and contact details of lead *and* partner organisations in all projects
- Maintaining a simple programme database that contains basic information on each project (on the participant, project title and abstract, award type and amount, timelines, etc.)

- Putting in place agreements with programme participants to allow programme information (proposals, proposal assessments, project reports) to be shared with an external contractor for the purposes of evaluation (under strict confidentiality / use restrictions)
- Making it an explicit condition of grants to contribute to evaluation activities (including post-grant)
- Obtaining, collating and making available (to an evaluator, and more widely) the public summaries that we understand projects have been required to produce on completion
- Introducing an end-of grant questionnaire to gather basic feedback on programme delivery and implementation, as well as semi-structured information on project achievements (publications, patents, TRL level, events held, etc.).

Appendix A Methodological Annex

A.1 Study approach

The study has been built on a mixed method approach, organised around four work packages, as follows:

- **WP1: Scoping** – The study started with a short inception period, consisting of an initial review of available programme documentation and data, the development of a programme logic model and framework to guide the evaluation, and the finalisation of plans to the main part of the evaluation.
- **WP2: Primary data collection** – The main phase of evidence gathering, consisting of a survey of all grant recipients, face-to-face discussion with a selection of participating organisations and interviews with programme management and other stakeholders.
- **WP3: Analysis** – A final phase, drawing together and analysing the various available information and evidence gathered through the study to address each of the key requirements and questions.

Throughout the study, a series of **reports and meetings (WP4)** were also planned. An inception meeting was held at the start of the contract (11th December 2017) to launch the study, while a scoping report and associated meeting (5th January 2018) marked the conclusion of the first phase. An interim presentation was given during the second phase (19th February), to update on progress and early findings, before a (draft) final report was delivered following the conclusion of analysis. A final meeting was held on 15th March, with further comments on the draft report also provided in writing after this. The revised final report was submitted to UKSA in May 2018.

A.2 Main methods

The main methods employed during the evaluation are outlined in the sub-sections below.

A.2.1 Document review

The study team conducted a review of programme documentation, including Strategies, Calls, the GSTP evaluation and NSTP1 Review. These fed into our overview presentation of the programme and also informed the development of research tools and analysis of results.

A.2.2 Portfolio analysis

We conducted a portfolio analysis using the programme and project level data available. The portfolio analysis provides an overview of the size, structure and key features of the programme, its funding elements, projects and grant recipient (lead and partner) organisations, as well as a (brief) description of the differences between the individual funding elements of the programme. This overview is presented as a stand-alone piece of analysis in Section of 3.4 of this final report, and has fed into other activities (e.g. sampling) and analysis (e.g. CBA).

A.2.3 CATI Survey of grant recipients

Consultation with programme participants has been central to our data collection activities. Our starting point has been a survey to collect standardised, and largely quantifiable information concerning impact, value for money and processes, from across the breadth of the programme.

Our unit of analysis has been the project managers of lead organisation for NSTP-funded projects (completed or ongoing). The survey request went to all NSTP2 leads and a selection of NSTP1 projects (selected from the 3 funding elements – FastTrack, Pathfinder and Flagship – that continued in NSTP2). We approached the lead organisation for all NSTP1 projects where contact details were available.

We drafted a questionnaire for lead organisation, designed to be applicable for both NSTP2 and NSTP1 projects, across all the different funding elements and different organisation types. We shared this draft questionnaire with the UKSA and incorporated the feedback received into the final version of the questionnaire. The questionnaire was signed-off on 11th January.

The study team put together a list of 119 projects (2 Flagship, 46 Fast Track, 27 Pathfinder and 44 GEI) for NSTP2, with a lead organisation identified in each case (56 unique organisations in total). Where organisations have led multiple projects, these do not always have the same contact point, and there are in fact 92 unique contacts across the portfolio of 119 projects. To avoid asking individuals to respond twice, we invited the small number of respondents with multiple projects (n=18) to answer the survey in relation to just one of their projects (randomly selected by the study team for them). We used FAME and web-searches to identify telephone numbers for each of the NSTP2 lead contacts.

Additionally, we had a list of 42 projects (4 Flagship, 28 Fast Track and 10 Pathfinder) from NSTP1, with a lead organisation identified in each case (30 unique organisations in total). Due to record keeping from this period it was not possible to obtain contact names and details for the whole portfolio of NSTP1 projects, and we only managed to obtain the necessary details to contact 14 individuals.

All NSTP2 project lead contacts were sent an introductory email by UKSA about the evaluation and were made aware that the study team would contact them. We launched the survey on 15th January, which was implemented by our partners, Perceptive Insight. The survey concluded three weeks later, on 2nd February, and had a total of 50 responses distributed as described in Table 5 and Table 6.

Table 5 NSTP1/2 Lead Contacts – CATI Survey response

Population	Target	Response
99 unique contacts identified (+tel.) - from 55 organisations	50 individuals to be surveyed	50 individuals surveyed (8 NSTP1 / 42 NSTP2) Covering 35 separate organisations

Table 6 NSTP1/2 Lead Contacts – CATI Survey response by grant type

Project Type	Number of Projects	Total awarded	CATI responses
GEI	44	£418,863	16
Pathfinder	27	£1,191,848	2
Fast Track	46	£4,818,919	10
Flagship	2	£2,000,000	14
NSTP2 - Total	**119**	**£8,429,630**	**42**

A.2.4 Survey of partner organisations

A version of the CATI survey was implemented in our dedicated online platform (Survey Monkey) for use with partner organisations.

Partner organisations were identified for 44 of the NSTP2 projects, but with no contact point or contact details available in these cases. Consequently, we wrote to NSTP2 lead contacts of projects involving one or more partner organisations, asking them to forward a link to the online survey to the contact point at each of their project partners. The partners were then asked to name their NSTP2 project in the survey. The survey remained open until 9th February and we had a total of 14 responses, as show below.

Table 7 NSTP2 Partner Organisations – Online survey response

Population	Target	Response
Total population unknown Includes at least 50 different organisations (the majority of whom have also lead NSTP2 projects)	-	16 responses received

A.2.5 Interviews

Alongside the surveys, we have conducted a series of interviews with participant organisations, members of the programme / project management team, and other stakeholders. These were mostly face-to-face interviews, seeking largely qualitative information concerning impact, value for money and processes, from across the breadth of the programme, and from different perspectives.

We drafted two main **interview guides** – one for participating organisations and one for programme/project management. The participant interviews were intended to:

- Gather information at organisation level, with a representative that has a good overview of the portfolio of projects supported by the NSTP, but also of space related research conducted in the organisation more generally (i.e. funded by other national and EU sources); and
- Gather further information on individual NSTP projects undertaken by the organisation. This did not duplicate, but rather enlarge the body of evidence collected through the survey, giving the opportunity to further understand how the various typologies of impact have materialised in the organisation (going beyond the more simplistic evidence that can be captured by surveys). This has helped to prepare selected examples and quotes, showcased in various sections in the report, that provide more colour across the typology of impacts.

The programme management interviews varied slightly depending on the position and expertise of the specific individual in question, but in each case looked to cover aspects relating to programme impact, value for money and delivery / implementation processes.

We wrote to all organisations that have accepted to take part in the programme of interviews via the CATI survey. In advance of the interview we prepared a summary of that organisation's project portfolio (the title, value, abstract and partners for each of its NSTP2 projects), as well as any survey responses received from leads within the organisation. This was used by the study team as background, to prepare for the discussion, as well as providing a useful introduction to discussions. We then ran through the interview guide, asking the interviewees to respond in general in relation to their organisations involvement in NSTP2, but pointing to specific projects where appropriate.

The programme of interviews began in late January and took place over a period of six weeks (to allow time to fit into people's diaries). We conducted a total of 34 interviews with individuals from 18 different **participating organisations**, with 1-2 representatives from the same organisation interviewed during the same visit (so as to cover both organisation and project-level perspectives). This was above our original target of 30 interviews. We also conducted six interviews with **programme management** staff and stakeholders, out of nine (individuals) suggested by UKSA.

Table 8 Interviews

Population	Target	Response
Programme management 10 individuals identified across UKSA and CEOI-ST	Approach all	6 interviews completed
NSTP1/2 Lead Organisations All individuals agreeing during CATI survey to being contacted further for the evaluation (49 individuals, spread across 29 organisations)	15 organisations (30 individuals)	Interviews completed with: 18 organisations (34 individuals)

A.3 Economic analysis

This section provides methodological explanations of our value for money (CBA) estimates. We first discuss the (gross) direct impact of the programme, based on the estimated value of commercial and non-commercial contracts emerging as a consequence of NSTP2 projects. This constitutes the direct impact of the programme. We then discuss knock-on effects for the economy, before calculating a net final impact figure that takes account of parameters such as deadweight.

It is important to note that the calculations in this section are based on the sample of (33) survey respondents only. They therefore represent an absolute minimum estimate for impact of the NSTP2. Following advice from UKSA, these are the figures brought through to the main report. However, at the end of this section we do briefly consider a simple extrapolation of the headline results, so as to give a sense of the possible scale of impact across the overall portfolio of 120 projects.

A.3.1 Gross direct impact

As mentioned in the main report (see Section 4.9), lead organisations were asked through the survey to provide their best estimates of the total value of contracts (commercial and non-commercial) that have emerged (or are expected to emerge) due to their participation in NSTP2, as well as the timeline for the start of this revenue and the probability that this would happen at all. Each organisation was asked to reflect on the effects generated by one specific NSTP2 project (i.e. one participation).

These parameters (probability, timescale, potential and additionality) have been captured through our survey in a qualitative way (e.g. low, medium, high probability of a project generating income) and have then been assigned quantitative values ex-post, as shown in Table 9. Mock examples of how those parameters have been applied is then shown in Table 10.

The calculations are then expressed in terms of net Present Value (NPV), discounting the stream of (expected) future income by a social rate of time preference (3.5% as recommended by HM Treasury Green Book, Annex 6). This has led to estimations of 'expected' NPV incomes using Bayesian probability (i.e. project generates £1M with 50% probability and £0 with 50% probability).

Table 9 CBA parameters

Probability of (additional) revenue / income streams	Value
%	
Currently generating revenue	100%
Very high	+70%
High	+50%- 70%
Medium	+20%- 50%
Low	+0%- 20%
None	0%

Timescale for start of additional revenue / income streams	Value
Currently	Now
Short term	1-2 years
Medium term	3-5 years
Long term	6+ years

Potential TOTAL value of contracts for 5-year period (when revenue starts)	Value
1	Less than £1 M
2	£1 M - £5M
3	+£5 M - £10M
4	+£10 M - £15M
5	+£15M

Additionality: Probablity of being able to achieve same results by other means (and not through NSTP)	Value
Very high	+70%
High	+50%- 70%
Medium	+20%- 50%
Low	+0%- 20%
None	0%

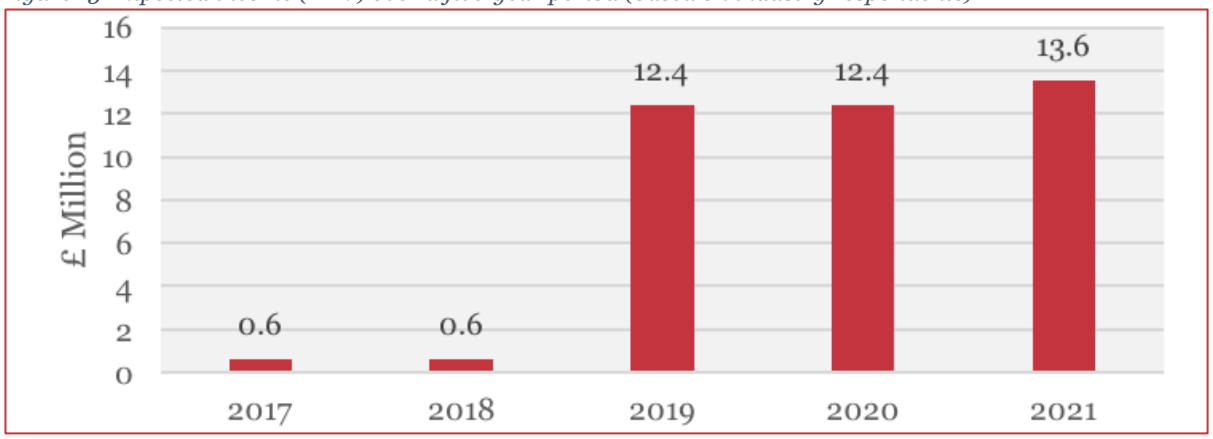
Table 10 CBA parameters - example

Project	Org.	Probability of (additional) revenue / income streams	Timescale for start of additional revenue / income streams	Potential TOTAL value of contracts for 5-year period (when revenue starts)	Probablity of being able to have made same progress by other means (and not through NSTP)	Additionality
Project 1	A	VH (+70%)	S (1-2 years)	£1 M - £5M	M (20%- 50%)	100% - Pr
Project 2	A	L (+0%- 20%)	M (3-5years)	+£10 M - £15M	H (50%- 70%)	100% - Pr
Project 3	B	Currently generating revenue	C (now)	Less than £1 M	None (0%)	100% - Pr

Lead organisations that took part in NSTP2 and responded to our survey expect to generate a total of £40.2M in (new) income over a 5-year period (in net present value). This implies an (average) annual income of £24K per participation (£8M across 33 respondent). We also collected similar data for partner organisations, but have not used this because of the small number of responses.

The figure below shows the result for industry participants only, based on survey responses. It shows that these companies have already (2017) seen an annual value of contracts attributable to the programme of £0.6M, and this is expected to grow to £13.6M per annum by 2021. This reflects the fact that 41% of industry participants expect income to materialise on 3-5 years from now.

Figure 15 Expected income (NPV) over a five-year period (based on industry respondents)



Source: NSTP2 survey of lead organisations (n=22)

The HM Treasury Green Book recommends the use of gross value added (GVA) (instead of turnover) as a measure of gross impact on sales. This is a better measure of economic impact than turnover, since it discounts the added value generated along the supply chain and avoids double counting.

GVA=Operating Profit + Employee Costs + (Depreciation – Amortisation)

We have used standard GVA: turnover ratios published by the ONS (and based on the Annual Business Survey). Specifically, using the ratio for the UK space economy (1:0.37[18]), we estimate the **gross direct impact of NSTP2 to be at least £14.9M**. This is based on the estimate of £40.2M contracts, provided by survey respondents.

[18] "Size and Health of the UK Space Industry" (2016)

A.3.2 Gross indirect and induced impact

The direct impact generated by participating organisations has, in turn, a knock-on effect on the wider economy, via two routes:

- Indirect impact – corresponding to the employment and activity supported across the supply chains of the NSTP2 participants generated by their additional (attributable) income.
- Induced impact – corresponding to the additional economic activity supported by people directly employed by NSTP2 participants and their suppliers, who spend their wages on goods and services in the wider economy. These purchases, in turn, help to support jobs in the industries that supply consumers with these goods and services (e.g. retail industry, banking sector, etc.).

Indirect and induced impacts can be estimated using a 'type II multiplier'. According to the "Size and Health of the UK Space Industry" report (2016), the type II multiplier (direct, indirect and induced) for the space sector is 1.97, implying that each £1 of space industry GVA (i.e. the direct impact) generates £0.97 worth of GVA in the supply chain and supporting sectors (i.e. the indirect and induced impact).

The three linked estimates (direct, indirect, and induced) amount to an estimated **total *gross* impact from the NSTP2 projects on the UK economy amounting of £29.4M.**

A.3.3 Total net impact

The HM Treasury Green Book recommends any estimate of gross effects should be adjusted (discounted) for several other factors in order to arrive at an estimate of *net* impact, including deadweight effects (organisations may have realised some or all of the benefits anyway as a result of their own investments, which may have been crowded out by public support), displacement (increased sales among assisted firms are largely accounted for by losses among their competitors elsewhere in the economy) and leakage (where benefits to UK-resident businesses flow out of the region or country where the taxes were collected that paid for the industry support).

In terms of **counterfactual**, very few survey respondents believed that their project would have gone ahead (at least in any kind of similar form) without NSTP2 funding. Overall 90% of respondents indicated through the survey that they would not have gone ahead with the project without NSTP2 funding, while the remaining 10% may have gone ahead (with other private / public funding), but usually more slowly, or in some other more limited way. Furthermore, most also reported little likelihood of achieving the same results (revenue and jobs from contracts resulting from their NSTP project) by other means (79% stating that the likelihood was low or zero).

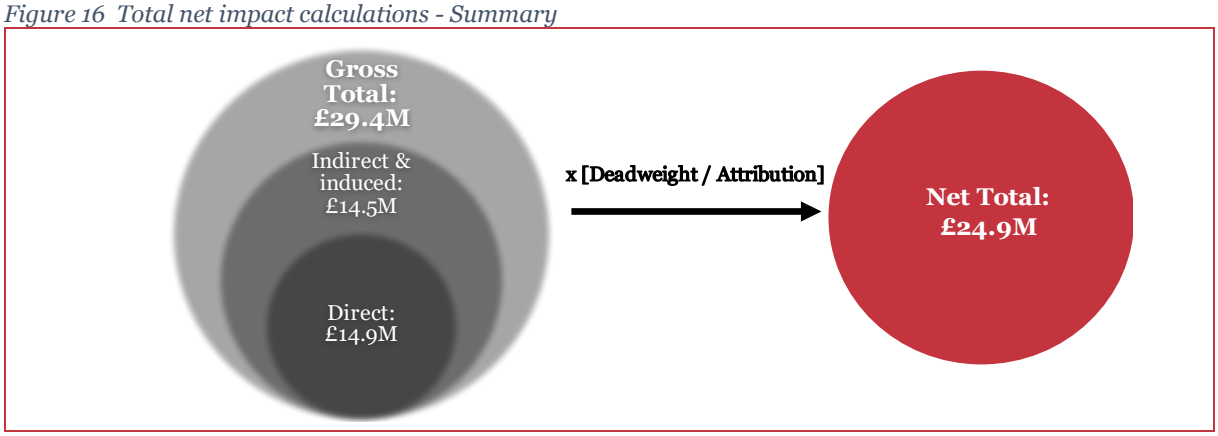
After accounting for deadweight, we estimate that the **total *net* impact of NSTP2** through the positive commercial benefits generated to our sample of participants **is £24.9M**[19].

[19] We also considered accounting for leakage (the extent to which impacts will materialise outside the UK) and displacement (the extent to which additional contracts for NSTP participant organisations are simply displacing other, non-participant, organisations in the UK and their ability to access those same contracts). There are no standard metrics to account for both factors. The "Return from Public Investment" study prepared by London Economics (2015), provides a literature review of 57 international studies on this topic and none of them account for displacement, while only one study (for Norway) accounts for leakage.

Both factors are expected to be close to zero in this case. We expect most of the contracts and future income to relate to the UK-based organisations. A degree of displacement, is expected, however given the cadre of support companies (i.e. the main UK companies working in the space sector) and its level of specialism, it is likely that they are competing with international companies rather than with UK based ones.

The figure below summarises our estimates, and the progression from direct impacts to total net impact.

Figure 16 Total net impact calculations - Summary



Source: Technopolis (2018). Based on 33 respondents.

A.3.4 Return on investment

We use our estimates of total net impact (£32.7M), combined with the public investment (grants) made by UKSA (£3.1M) to arrive to an estimate on Return on Investment (RoI) for the 33 NSTP2 projects covered. Specifically, we estimate that NSTP2, at a minimum, will have a return on investment of 7.0, taking into account the expected value of contracts over the next 5 years. This means that **each £1 invested in NSTP2 will generate a (net) impact of £7 over a 5-year period** (2017-2021). Coincidentally, this RoI is the same as that estimated in the recent evaluation of the UK participation in the ESA General Scientific Technology Programme (GSTP), providing extra confidence in our results.

In addition, the investments made by the UKSA have also **leveraged funding** across organisations / participations, which in some cases goes beyond the legal requirements because organisations (especially companies) are prepared to top up their original commitments to drive the project to a successful conclusion. This has been the case in one of the Flagship projects for instance, where the original co-funding from industrial partner organisations have gone from £0.8.M to £1.3M. This was mainly because the industrial partners foresaw a substantial revenue stream of approximately £5-£10M, and therefore saw a clear business case to keep on investing in the project.

Based on survey responses regarding funding leverage (20 responses) we estimate that a budget of £2.6M (NSTP grants going to these survey respondents) leads to a co-funding of £1.4M, i.e. each £1 of (public) funding leads to an additional £0.54 in investments from participants.

Table 11 Leverage

	Respondents	Budget (in £M)*	Co-funding (in £M)
Fast Track	9	0.8	0.2
Flagship**	2	1.5	0.9
Pathfinder	9	0.3	0.2
Total	**20**	**2.6**	**1.4**

Source: Technopolis (2018). *Corresponding to budget per project per organisations. **Data in the survey corresponds only to one organisation on the Flagship project not across all partner organisations

A.3.5 Extrapolation

Following advice from UKSA, the figures presented above (and in the main body of this report) are based only on the responses received through the surveys conducted for the study. These responses relate to 33 of the 120 projects that form the entire NSTP2 portfolio and so the results represent an absolute minimum estimate of impact. The actual scale of impact will be considerably higher.

The individual projects within the portfolio vary in various respects (their size and scale, starting TRL, technological focus, aims and intentions) and we would therefore expect the potential scale of any economic impact to vary considerably between projects. Nevertheless, with a reasonably large sample covered through the survey (33 of 120 projects, or 27.5% of the project portfolio), and a largely random selection of projects (projects were included at random for inclusion and there was only one refusal to provide a response), it is not unreasonable to consider the scale of impact that may be achieved by the NSTP2 portfolio as a whole, based on a **simple linear extrapolation** from the survey sample results.

Following the process set out earlier in this section, but extrapolating from the 33 respondents to the full portfolio of 120 NSTP2 projects, we estimate that the developments supported across the portfolio will lead to £144.2M in new commercial and non-commercial revenue for participating organisations, which in GVA terms equates to **£53.4M in gross direct impact**. After including indirect and induced impacts, and taking account deadweight, we arrive at an overall 'grossed-up' **total net impact** from NSTP2-supported developments **of £89.1M**.

Based on the public investments through all NSTP2 grants, the **return on investment** to the programme *as a whole* is estimated to be **10:1**. The grossed-up and non-grossed-up RoI estimates are different because respondents represent 37% of the programme budget, but only 28% of participations.

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