UK SPACE AGENCY

National Space Technology Programme


UK SPACE
AGENCY

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PROGRAMME OVERVIEW

Introduction

Space technology is critical in providing UK citizens and businesses with the public infrastructure and security necessary to underpin societal and economic wellbeing.

The National Space Technology Programme (NSTP) launched in 2011 as a result of the Space Innovation and Growth Strategy's recommendation to "increase the UK's returns from Europe by continuing to grow the UK's contributions to European Space Agency (ESA) programmes and securing greater influence in large European-funded programmes."

NSTP exists to develop space technology and capabilities, underpinning growth in the UK economy, as set out in the UK Civil Space Strategy. A central aim of the programme is to sufficiently de-risk technologies to become commercially attractive propositions. We are ensuring that future space technologies are investigated, understood and nurtured.

New partnerships forged through NSTP funding have helped organisations of all shapes and sizes to capture new business and enable companies to position themselves for further funding and investment opportunities. NSTP has also helped established companies to move into the space sector, directly contributing to the national space growth agenda.

There have been two comprehensive evaluations of the NSTP to date. The first was completed and published on our website in November 2014. The second was completed and published in July 2018; a summary of which is published at the back of this booklet which I encourage you to read. The full, final reports of both evaluations are freely available on www.gov.uk/ukspaceagency. With the third phase of the programme coming to an end, a third review will commence later in 2022.

The activities described in this document provide just a taster of some of the projects that we have funded across the 5 technology areas and 4 NSTP funding streams, of which you can find more detail in the following chapter.

For more information on the National Space Technology Programme, please contact the team on nstp@ukspaceagency.gov.uk.

Prof. Chris Castelli
Director of Programmes - UK Space Agency

Developing Space Technology in the UK

The National Space Technology Programme is a capability programme encouraging the development of the space technology sector in the UK.

The UK Space Agency's aim is to drive growth in the UK economy, supporting the development of space technology and skills as embodied in the UK Space Innovation and Growth Strategy.

NSTP offers support by funding industry, academia and other (not for profit) institutions who are looking to develop technology and build capability in the UK space sector, offering funding for organisations of all sizes, from start-ups to those more established on projects both large and small to contribute to the growth of the UK economy. Collaboration between organisations is strongly encouraged. The programme funds projects across five themes through the four funding types outlined on the next page.

Access to Space
Typical activities might include but are not limited to: space-plane/ reusable launch systems; small satellite launcher and sub-orbital spaceplanes; small and nano platform technologies; Inter-orbital transfer capability; fuel and propellant technologies.

Sensing
Typical activities might include but are not limited to: ultra violet,visible, infra-red and x-ray detectors; optical systems and lidar; active and passive microwave sensing systems; in-situ instruments; down-stream technologies and earth observation applications.

Position, Navigation & Timing
Typical activities might include but are not limited to: quantum precision; clocks and timing mechanisms; securing and exploiting navigation systems for increased security and Radio Frequency electronic equipment including navigation.

Robotics & Exploration
Typical activities might include but are not limited to: autonomous vehicles; robotic manipulators; novel power technologies; robotic support of manned exploration; robotic control and rendezvous and docking.

Telecommunications
Typical activities might include but are not limited to: turnkey satellite systems; spacecraft platform, structure and composites; payload systems capability; satellite network operations, business support systems, services and applications; radio frequency electronic equipment including telecoms, communications for science and exploration missions.

Overview of Funding Types

Grants for Exploratory Ideas (GEI) £15k maximum funding for 3 month duration

Pathfinders £75k maximum funding for 6 month duration

Fast Track £200k maximum funding for 12 month duration

Flagship £1m maximum funding for 24 month duration

For more information please refer to the Missions and Programmes on www.gov.uk/government/organisations/uk-space-agency

CASE STUDIES

Demonstration of satellite-enabled drones in beyond visual line-of-sight operations as a proof-of-concept to support remote healthcare networks.

Snowdonia Aerospace
NSTP3 joint project with UK Space Agency Space for Smarter Government team and the Welsh Government

Snowdonia Aerospace Centre

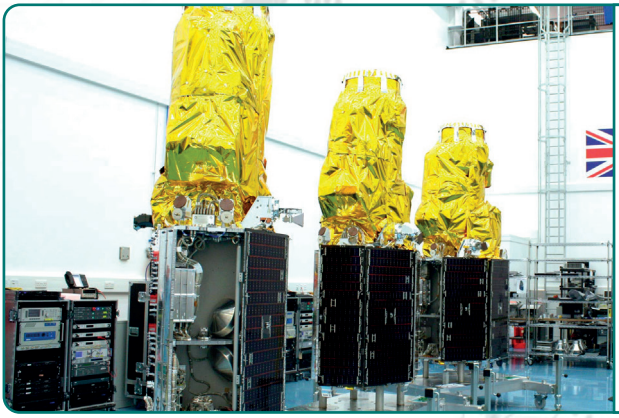
Snowdonia Aerospace, SwiftFlight Avionics, University of Manchester and the Welsh Ambulance Service, have completed a demonstration that showed proof-of-concept for beyond visual line-of-sight (BVLOS) delivery of a defibrillator by drone to a remote, rural location that would be difficult to reach with an ambulance in a timely fashion. Research suggests cardiac arrest survival rate of 50-70% could be achieved with defibrillation within 3-5 minutes, but each minute of delay reduces the probability by 10%.

The Schiller FRED Easyport mini-defibrillator was delivered by parachute to a "first aider" and "casualty" on a remote beach 4.5 kilometres from the launch location and took under 3 minutes to complete, whereas an ambulance would have taken 20+ minutes for the same journey. The project was conducted at the Snowdonia Aerospace Centre and showed how satellite-enabled drones could be used as part of a broader satellite-enabled network to support remote healthcare in Welsh communities.

STAR - Super-High Temperature Resistojets for All-Electric Telecommunication Satellites

Southampton University
Flagship

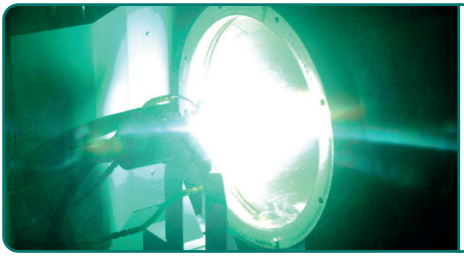
The STAR consortium has provided a highly innovative and disruptive electric propulsion option to enable a new generation of geostationary (GEO) telecommunication satellites and low Earth orbit (LEO) spacecraft to augment this UK strength. SSTL provided detailed mission requirements to implement the STAR technology in their LEO platforms. The University of Southampton has designed and tested the breakthrough electric propulsion system, which is enabled by a novel patented electric heater and design freedom offered by additive manufacturing (AM). The STAR thruster is the world-first high-temperature resistojet, operating consistently at > 2,000 K with xenon propellant. H.C. Starck Solutions (HCSS) was brought into the consortium for their expertise in refractory metal powders to achieve this goal, while HiETA Technologies Ltd (HTL) successfully produced components in these novel materials. Satellite Applications Catapult provided guidance in the supply chain strategy and production standardization for scale up production. The next step consists of commercialising the STAR technology through the University of Southampton spinoff OhmSpace.



Testing

The combustion chamber was tested at AEL's Westcott propulsion test facility with excellent performance. This was the first AM copper chamber to be fired in Europe, and demonstrated responsive propulsion design, build and test purely within the UK supply chain.

ACKNOWLEDGEMENT
The principal investigator Dr Angelo Grubisic sadly passed away in August 2019.
The STAR project success is due to his research vision and passion about space technology.

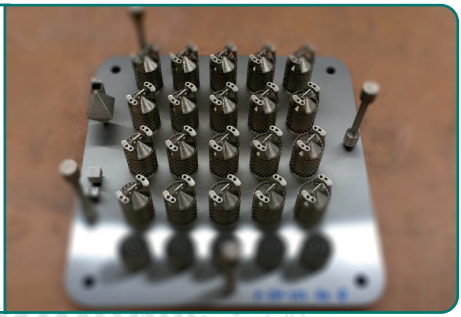


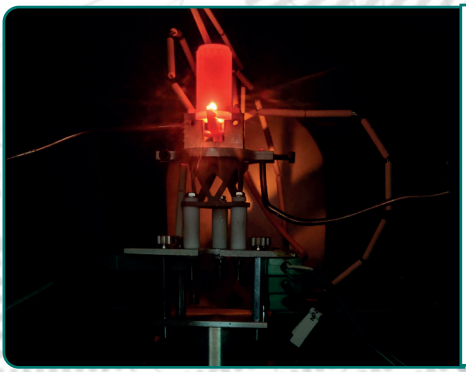
Refractory Metal Powders

HCS successfully produced low-oxygen refractory powders with their in-house R&D scale plasma spheroidization system. A special Ta10W alloy was produced in a batch of 32 kg to operate the electric heater to temperatures exceeding 2,000K.

Additive Manufacturing

HTL produced batches of components exceeding twenty elements in Ni-alloys and components in refractory powders supplied by HCS in their experimental reduced build volume. HTL has built the capacity to successfully produce components using the novel refractory materials.



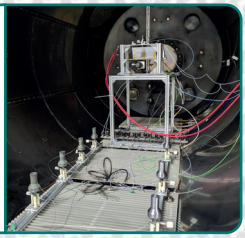


Innovative Resistojet Design

The underlying innovation of the STAR thruster is the patented highly compact electric heater, which is characterised by an extremely complex design but produced in a single printing process. The novel design results in extreme temperatures being generated in the interior of the thruster, maximising propellant efficiency and allowing high reliability.

Testing And Results

Endurance tests on eight engineering model (EM) thrusters exceeded the lifetime and performance requirements described by SSTL and more broadly by the industry. The refractory EM thrusters exceeded 10,000 heating cycles while maintaining the same performance of specific impulse superior to 60s.



Oil field fibre-optic sensing technology for space deployment

Rushton Electronics
Grant for Exploratory Ideas

Rushton Electronics

Well·SENSE

Fibre-optic sensors are used in oil wells to measure temperature, vibration and other data. These measurements are used to build a model of the well and the surrounding rock structure, to accurately locate valuable hydrocarbons, to plan future production, and more. The ability to accurately locate resources will be crucial for space exploration from searching for water on Moon to finding the materials for Martian colonies.

We are investigating the use of sensors where the fibre itself is used as a sensor, which can be several kilometres long. The fibre is sensitive along its whole length, providing a large amount of information. Made from glass about 4 times thickness of a human hair, their low mass makes them ideal for space. An opto-electronics module is also required and we are working to make this as compact as possible. We are also adapting deployment technologies to enable their use on rovers.

Preparation for a parabolic flight campaign to test the feasibility of using a novel supine jump sled as an exercise countermeasure in microgravity

St Mary's University and Physical Mind London Joint project with the UK Space Agency's Exploration and Robotics Programme

Spending a prolonged period of time in space causes a reduction in physical fitness including a loss of muscle and bone strength. For this reason, astronauts on the International Space Station spend a considerable proportion of their working day performing countermeasure exercise. Exercising in microgravity is a challenge, and current devices are bulky and inefficient.

Physical Mind London designed and built a novel multi-exercise device called 'High Frequency Impulse for Microgravity' (HIFIm) which allows astronauts and parastronauts to perform jumping and hopping exercises in space: HIFIm is specifically engineered to overcome the constraints of transmitting forces and vibrations to the spacecraft when in use. Jumping activities have been proven to be a highly effective form of exercise countermeasure as they require large muscle forces and these forces are transmitted to the skeleton.

John Kennett (left), Dr Tess Morris-Paterson (on HIFIm centre), Dr Daniel Cleather (right)

Since concluding this initial preparatory project, the planned parabolic flight campaign has completed and post flight analysis is ongoing. The HIFIm test team included a lower limb, single leg amputee to assess the feasibility of HIFIm's capability for maintaining the health of both astronauts and parastronauts. This was successfully demonstrated in zero gravity, on the parabolic flight campaign, proving that jumping using HIFIm in zero gravity is possible and reduced the loading on the supporting structure.

The success of this test flight campaign has taken HIFIm to Technological Readiness Level 6.

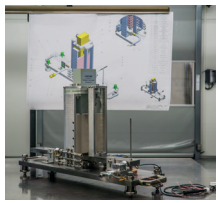
Thrust Balance

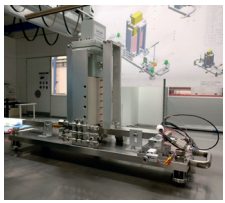
AVS UK
Pathfinder

The goal of this Pathfinder project was to design, build and test a new thrust balance system as an upgrade for the Electric Propulsion (EP) lab at the Surrey Space Centre (SSC). The work was led by AVS UK in close collaboration with SSC. Following this proof-of-concept, our balance design will be developed as a commercial unit for other propulsion test facilities.
The number of companies and research institutes that are in various stages of small- and nanosat propulsion development is growing dramatically; all of them require a suitable balance. AVS' own development roadmap covering a broad range of thruster technologies also greatly benefits from this in-house thrust balance design.

As the small- and nanosat market matures, increasingly capable spacecraft and challenging mission profiles are in high demand. Often this goes hand in hand with development of a new generation of miniaturised, high-performance propulsion systems. Given the power, mass and volume constraints arising from nanosat platforms in particular, the vast majority of these systems produce thrust levels in the micro- to few milli-Newton (mN) range, precision thrust balances are needed to accurately measure such low forces. Building these balances with sufficient accuracy and repeatability to confidently quantify propulsive performance is a non-trivial task.

We successfully designed, manufactured, assembled and tested our balance. A first test run in vacuum with a cold gas thruster validated core functionality. Further tests using AVS and SSC's internal resources will now be carried out to extend characterisation and improve performance with a range of thrusters.. The project has led to commercial interest from a prime outside the EU, AVS is currently in negotiations to build a commercial version of the balance for them.





Additive manufacture of CubeSat mirrors

Science and Technology Facilities Council Pathfinder

CubeSat telescopes offer a low cost, rapid turnaround option for niche applications and technology demonstrators. Conventional manufacture of lightweight, high precision mirrors can be prohibitively expensive for CubeSats; however, additive manufacture (AM; 3D printing) has the potential to provide innovative design solutions, to reduce mass and mounting interfaces at low manufacture cost - assuming the required optical quality can be achieved.

The project objective was to design, fabricate and evaluate five AM metal mirrors for integration within a 3U CubeSat chassis. The mirrors shared an identical design, but each mirror had a unique manufacture route - allowing for a like-for-like comparison.

In parallel, an optimisation study was conducted to explore how AM techniques could be applied to enhance the fabricated mirror design.

The evaluation of the AM metal mirrors demonstrated suitability for applications between near-infrared and ultra-violet wavelengths; coupled with design optimisation, AM mirrors have the potential for more integrated functionality and mass reduction than conventional mirrors. This project was a collaborative effort between: the UK Astronomy Technology Centre, University College London, University of Durham, University of Sheffield, the National Physical Laboratory and the Diamond Light Source.

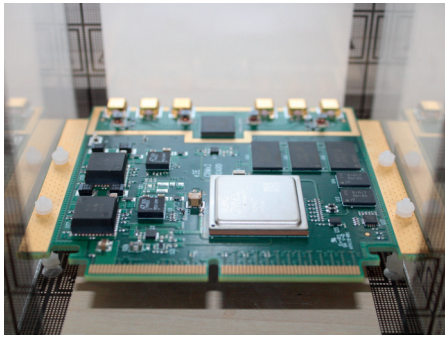
CAPEBEST – Critical Asset Protection Enabled By Emerging Space Technology

e2E Services Ltd.
Fast Track

Damage to undersea assets and platforms mostly due to shipping activity, is a significant global problem. This is exacerbated by limitations of Automatic Identification Systems (AIS) that are constrained to coastline communications or need to operate in busy areas bringing congestion and capacity issues.

This UKSA NSTP Grant enabled e2E to undertake in partnership with UltraMAP Ltd (vessel management applications) & Assimila Ltd (remote sensing), an in-depth analysis and feasibility study to assess the potential use of AIS and VDES-like equipped High Altitude Pseudo Satellites (HAPS) as an option to traditional satellite systems.

A technical solution is engineered, balanced with an informed assessment of the addressable market, legislative status, economic outlook, and commercial viability of operating the solution. The Project is called CAPEBEST (Critical Asset Protection Enabled by Emerging Space Technology) and the aim is to undertake stratospheric Lighter-than-Air balloon-based demonstrations when readiness levels, market conditions and investment requirements align.



NSTP EVALUATION

Scope and Summary of Findings

The UK Space Agency commissioned Technopolis to evaluate the NSTP, focusing on its second round of funding (NSTP2, projects launched between 2014-2016). 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, all of which have been covered extensively in the full report.

It is important to note that most NSTP2 projects had only recently concluded (or were still ongoing) at the time of this evaluation.

Therefore, 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. As such, findings are only preliminary at this stage. The infographic opposite highlights some of the key findings which came out of the evaluation.

- 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 lead organisations 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 lead organisations 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

The full document can be accessed via the UK Government web-pages:

https://www.gov.uk/government/ publications/evaluation-of-the-national- spacetechnology-programme-nstp

The UK Space Agency would like to thank: All of the organisations and participants that contributed to this evaluation, Neil Brown Cristina Rosemberg, Fraser Macleod, Charlotte Glass & Paul Simmonds of Technopolis |group| United Kingdom for their time and effort in compiling their report on behalf of the UK Space Agency.

NSTP 4 was launched in 2021. An evaluation of NSTP 3, projects launched 2017-2020 will take place in 2022.

National Space Technology Programme 2 *Key Impacts*

UK SPACE AGENCY

OBJECTIVES

- Developing UK space technology and capabilities
- De-risking technologies sufficiently to become attractive propositions for further investment
- Increasing the UK's return from European space-related programmes
- Growing the size and value of the UK space sector
- Positioning the UK to benefit from future space technologies

RAISED TRL LEVELS

67% of lead organisations report: TRL 1-2 → TRL 3+

On application to NSTP2

At end of NSTP2 project

86% of lead organisations report: TRL 3-4 → TRL 5+

PROJECT PORTFOLIO

120 projects	£8.4M in grants	£69K average per project
45	Grants for Exploratory Ideas (GEI)	£10K max
27	Pathfinder projects	£50K max
45	Fast Track projects	£150K max
2	Flagship initiatives	£1M

CODIFYING KNOWLEDGE AND KNOWLEDGE TRANSFER

- **16** publications in refereed journals
- **55** other publications
- **7** patent applications

produced by 54 respondents (~1/4 of all participations)

PROJECTS DE-RISKED

lead organisations report

- **63%** reduction in the cost of their project idea or technology
- **77%** reduced the time to market

INCREASED VISIBILITY AND REPUTATION

+90% of lead organisations report increased attractiveness to institutional funders and likelihood of securing future contracts

95% of NSTP lead organisations report improvements to internal knowledge, skills and capabilities

ECONOMIC IMPACT

£24.9M in estimated net impact

based on 33 respondents (~1/4 of NSTP2 project leads)

£7:1 return on investment (RoI)

79 jobs created or safeguarded

based on 39 projects (~1/3 of NSTP2 portfolio)

ENCOURAGING STRATEGIC PARTNERSHIPS

between industry and academia

HALF of supported projects include multi-organisation collaboration

93 separate UK-based organisations involved

- **69** Companies
- **21** Universities
- **3** other government-funded bodies

70% of lead organisations reported that their NSTP2 partners included ***new*** **collaborators**

technopolis |group|

UK Space Agency

The UK Space Agency leads the UK efforts to explore and benefit from space. It works to ensure that our investments in science and technology bring about real benefit to the UK and to our everyday lives. The Agency is responsible for all strategic decisions on the UK civil space programme. As part of the Department for Business,

Energy & Industrial Strategy, the UK Space Agency helps realise the government's ambition to grow our industry's share of the global space market to 10% by 2030.

The UK Space Agency:

- supports the work of the UK space sector, raising the profile of space activities at home and abroad.
- helps increase understanding of our place in the universe, through science and exploration and its practical benefits.
- inspires the next generation of UK scientists and engineers.
- regulates and licences the launch and operation of UK spacecraft, launch operators and spaceports.
- promotes co-operation and participation in the European Space Agency and with our international partners.

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