

UK Sats: The UK Satellite Programme Leading Global Space & Partnerships

A White Paper from the Space Academic Network

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Modified version of SPAN's SciSat Paper from 2019

Version 4, 22nd March 2024

Introduction

The UKSA Bilateral Programmes (Science and Industry) enable UK to partake in missions outside of ESA with partners, however UK is a minor partner. The sector has long expressed a wish for sovereign UK lead missions. This document expands the original concept of science targeted missions to all uses in Space. This document is a development of a SPAN White Paper put together in 2019 on so-called Sci-Sats. Due to time and resource constraints on SPAN and its members this document has been assembled by SPAN Co-chair Prof. Mark Sims and SPAN Liaison Manager Anushka Sharma and is based on a survey of members and discussions at the Space Engineering and Technology Working Group and Space Science and Exploration Working Group in March 2024. Any errors in interpretation of the discussions are the responsibility of the Co-Chair Prof. Sims.

Please note in what follows Space Science means space based science and hence includes all aspects EO, Technology Development, Microgravity Research as well as Space Science such as Astronomy, Plasma Physics and Planetary Science.

Vision

To establish a sovereign national programme for the development of new world-leading Space based research and technology demonstration using small satellite technology and missions to accelerate and demonstrate UK leadership. To help drive growth and where appropriate international relationships. To provide a national route for rapid access to space and collect new and unique data sets and enable in-orbit demonstrations. To enable the sector to compete internationally with other space faring nations with well-funded national programmes and to train the next generation of space scientists, industrialists and engineers feeding the “New Space” economy. To feed into new international collaborations for example, through UK contributions to bilateral missions.

Why Now?

- Given the lack of a national programme of missions, there are limited opportunities for the UK sector to develop and demonstrate their leading space based science and engineering capabilities.
- Opportunities through ESA, bi-laterals and existing UK funding are too few and too infrequent – these are often focussed on a current or near-term (close to market) industrial cases rather than medium to long term development.
- Major investment is needed to provide an opportunity to lead in strategic technologies and applications of national importance such as sensing, navigation, cyber, climate, quantum etc.
- UK Space Research Institutions and Industry could embrace *New Space* approaches with a fast, responsive, and agile programme to accelerate innovation using nanosats, micro and small satellites.
- The US, France, Germany, Italy and other countries all have established mission programmes, and this provides fertile ground for economic development plus bi-lateral and larger space

missions.

What will be the Impacts?

- An invigorated space science and engineering scene that develops novel ideas and grows existing communities.
 - The programme will be a beacon for the space sector utilising UK industry and UK launch to offer opportunities for students, graduates, researchers, entrepreneurs and investors.
 - UK Space Research Institutions will be able to partner with UK Space Industry in the delivery of these missions, helping to strengthen the UK space ecosystem – growing the knowledge economy.
 - It will support UKSA international programmes with opportunities for international partnerships, leading to stronger trade relations and supporting Government political ambitions linked to MoUs signed with other national space agencies.
 - It will provide a long-term pipeline of talent, ideas and innovation to boost the economy providing the next generation of leading scientists, engineers, reviewers, industry leaders.
 - It will deliver transformative UK expertise and capabilities with clear routes to exploitation.
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Introduction

A UK Satellite Programme is being proposed where there will be a funnel of activities through three stages or phases. There will be an annual call for payload and platform studies enabling broad UK participation for early mission and systems studies, bread boarding and early development activities. The early phase studies will provide progression of low TRL technologies and form the basis of the national programme that delivers transformative UK expertise and capabilities with clear routes to exploitation. A key element will be development of novel and strategic technologies to enable the science or exploitation, including those that may result in medium to long term exploitation following the initial mission demonstration.

Figure 1 shows the logic and flow of the activities for a science lead mission, for application or technology missions replace science with appropriate titles, noting that some studies may exit from the programme to follow other routes to access space and implement their missions or will need to iterate in Phase A&B. The parallel studies will be down-selected for the following phases of Engineering Implementation and Validation (Phase C&D), and Ground and In-Orbit Demonstration (Phase E&F). A summary of these phases is in Table 1.

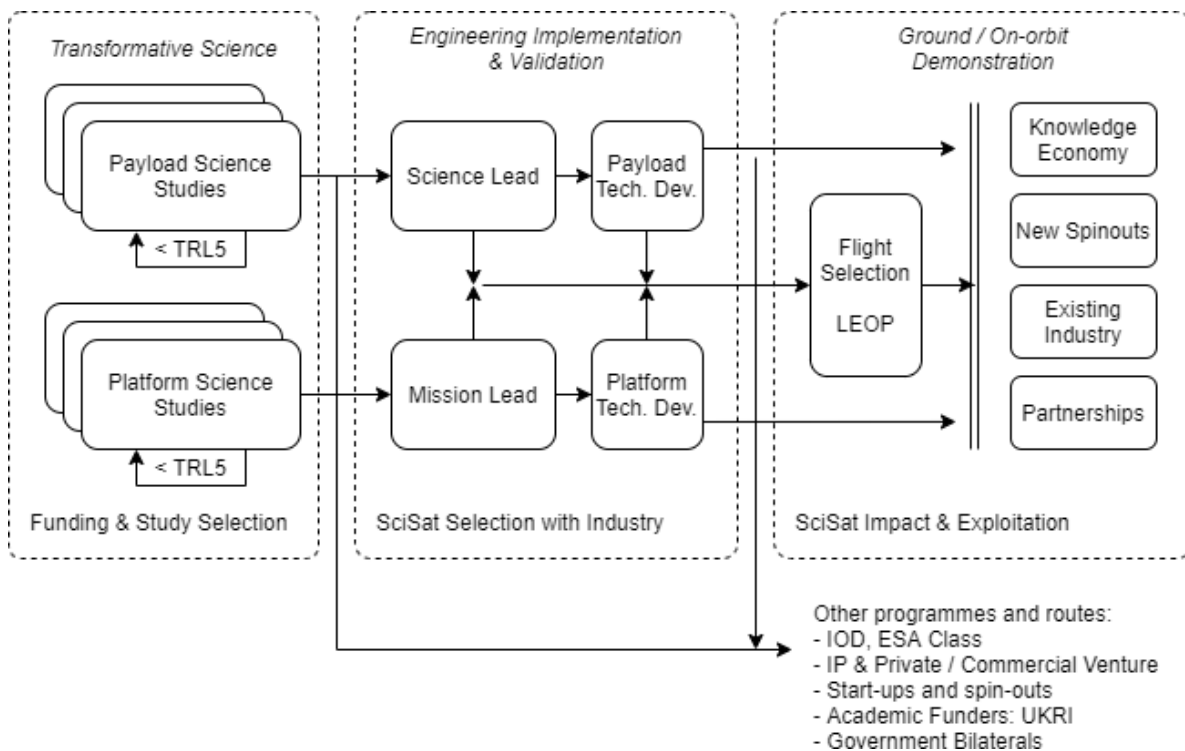


Figure 1: UK Sovereign Satellite Programme Structure: Science Example

Table 1: UKSat Programme Phases

Stage	Equivalent ESA Phase	Activity	Gate to Progress
Proposal with Science justification	Phase 0	Mission Analysis and Identification	Review Panel
Science Studies	Phase A and B	Feasibility and Preliminary Definition	Critical Design Review
Engineering Implementation and Validation	Phase C and D	Detailed Definition, Qualification and Production	Final Acceptance Review
Ground and In-Orbit Demonstration	Phase E and F	Utilisation and Disposal	

The principles are:

- The studies can iterate within that phase until they pass the Critical Design Review or exit into another flight programme or funding stream. It is worth noting that many studies may not be considered not feasible and do not progress – this isn't a bad thing.
- Iteration of the studies with further funding will depend on successfully passing the proposal review panel again.
- Studies will inform the budgetary envelope for the Engineering Implementation and Validation, and Ground and In-Orbit Demonstration activities.
- It is expected that study leads will work with industry after selection of the studies to develop the mission including areas such as technologies, define and deliver platforms, launch, operations and end-of-life activities.
- The structure has the benefit of an underlying funding level that is constant for payload and platform studies whilst forecasting the budget for the subsequent years. To achieve this we need longer term budget cycles (3-4 years) and ideally 10 years with a 15 year total forward look.
- This structure allows for ambitious and challenging mission ideas to be advanced with the understanding that some will fail to reach launch. Some may launch and fail to achieve their mission objectives, but this will not be from inexperience or failure to complete ground testing, but from aiming to do challenging things.
- Some studies will find other routes to fulfilling their objectives. In effect, a main objective is to provide mission seed funding and a kick starter route to strengthen UK success and leadership.

The review panel for the studies will be drawn from the UK's top scientists, representatives of industry (perhaps via UK Space) and Space administrators from across UKRI, UKSA and SPAN.

Selection of Studies

The primary aim of this programme is to progress new space science, applications and the enabling technologies.

The applied science will include the categories astrophysics, astronomy and cosmology, Earth observation and science, solar, lunar and planetary science, astrobiology, microgravity and life sciences.

The enabling science and technology must demonstrate critical advances that enable future missions and space capabilities such as engineering systems, propulsion and robotics. Science Studies could be pathfinders for future larger missions, securing a UK leading role.

The criteria for selection are:

- Unique mission or science concepts where there is no prior measurement or technology demonstration or published result.
- A balance daring and ambition & risk with a credible route to the creation of transformative science, technology, or datasets.
- The team has the capabilities to deliver a fully integrated satellite that can pass a Final Acceptance Review and that can complete the mission objectives.
- A preliminary high-level project plan for launch and operations and will describe the contingency therein and risk retirement activities.
- A preliminary financial plan and show that the mission can be completed in the budget available.
- A preliminary launch, orbit and operation requirements, and will have identified a route to achieve these.

Selection of Studies for Engineering Implementation and Validation

The studies will conclude with a Critical Design Review. To pass the CDR the following will have to be demonstrated:

- Confirmation of the feasibility of the initial proposal and demonstration of return on investment for the UK. The metrics for successful return on investment need to be defined, and any mission with commercial exploitation potential will exit the programme or establish co-funding in proportion to the weighting of science and commercial exploitation.
- Retirement of risk in accordance with the initial plan, or a route to recovering the position successfully within three months.
- Successful completion of breadboarding and development activities in accordance with the proposal.
- A project plan for Phases C-F with a description of the contingency therein and risk retirement activities.
- A financial plan for Phase C-F demonstrating that the mission can be completed in the budget requested.
- Confirmed launch, orbit and operation requirements, and the route to achieve these.
- Allocation of resources and availability of all necessary facilities for completion of Phases C&D.

The CDR will be run by the Programme Review Board which will be from UKRI, UKSA, SPAN and Industry.

Selection of Missions for Ground and In-Orbit Demonstration

Phases C&D will conclude with a Final Acceptance Review (FAR). To pass the FAR the following will have to be demonstrated:

- Successful build and integration of all sub-systems into the satellite
- Successful completion of all screening tests
- The team and resources are in-place to manage the operations after launch
- The plan to retrieve, store and analyse the data is in place
- All regulatory requirements are met and allocation of radio spectrum for operations has been granted.
- The plan for engagement with undergraduate teaching and postgraduate (where appropriate) training is in place through the mission operations and utilisation of the data
- A plan and means to execute a publicity campaign are in place and is coordinated with UKSA

The FAR will be run by the Programme Review Board.

Programme Review Board

The programme review board would include UKRI, UKSA, Industry and SPAN. There is scope to invite other stakeholders such as the Satellite Applications Catapult and DSTL.

For science missions with no obvious commercial exploitation, the role of industry will be to advise on technical, financial and operational feasibility.

For science missions with near term commercial exploitation, industry may be stakeholders in the commercial exploitation of the mission and co-funding partners.

Missions that develop a very strong near to medium term commercial exploitation will exit the programme at CDR and be funded by other means. If they exit the programme at FAR, the investment in Phases C&D will be returned to the programme.

The Programme Review Board will have at its core the review panel for the science studies, and will be augmented for each of the CDR and FAR meetings on a case by case and mission by mission basis.

Timescales

Each phase will last nominally two years but mission development cycles and overall length will vary dependent on use.

Costs

It is estimated that costs will be £4M p.a. for Phase A&B **plus** costs (TBD) to run the programme. Phases C&D and E&F would be bid accordingly or sized accordingly based on the funnel of Phase A&B studies. It is hoped that the programme would grow rapidly to a multiyear steady state level of funding. The total cost of the programme once fully established would be £18M - £25M p.a.

Signatures of Support

The following people support the proposed SciSat programme in their personal capacity in 2019, showing breadth across the UK space research community for such a programme.

Table of signatories from paper publication date Version 3, 29th June 2020

Prof. Malcolm Macdonald University of Strathclyde	Prof. Mark Sims University of Leicester and SPAN Board Member	Prof. David Stupples City University London	Prof. Andrew Holland The Open University and Chair of SPAN
Dr Kevin Worrall University of Glasgow	Dr Chris Bridges University of Surrey Surrey Space Centre	Paul Eccleston Chief Engineer RAL Space	Mike Curtis-Rouse Satellite Applications Catapult
Dr William Crofts Director of Warwick Satellite Programme	Kristina Tamane Space BD Executive University of Edinburgh	Prof. Mini Saaj University of Lincoln	Dr Katharine Smith University of Manchester

Dr Eamon Scullion University of Northumbria	Dr Alexander Valavanis University of Leeds	Dr Aaron Knoll Imperial College London	Prof. Adam Amara University of Surrey
Jerome Woodwark University of Edinburgh	Prof. Lucy Berthoud University of Bristol	Dr Neil Bowles University of Oxford	Dr Ian Parry University of Cambridge
Dr Peter Shaw Kingston University	Prof. Richard Massey University of Durham	Dr Biagio Forte University of Bath	Dr Mark Post University of York
Dr Chantal Cappelletti University of Nottingham	Dr Yun-Hang Cho University of Sheffield	Dr Joan Pau Sanchez Cuartielles Cranfield University	Prof. Hugh Lewis University of Southampton
Dr Richard Ghail Royal Holloway University of London			

Additional inputs and signatures from version 4, 21st March 2024 comprising written survey responses from SPAN members through the period August 2023 – Jan 2024. Followed by tabled discussions at SPAN Space Engineering and Technology Working Group (SETWG) on 20th February 2024 and SPAN Science and Exploration Working Group (SSEWG) on 21st March 2024.

Anushka Sharma Space Academic Network	SETWG Meeting attendees Feb 2024	SSEWG Meeting attendees March 2024	Survey Responses
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