UK SPACE AGENCY

CONSULTATION ON DRAFT NATIONAL STRATEGY FOR SPACE ENVIRONMENTS AND HUMAN SPACEFLIGHT

GOVERNMENT RESPONSE

16 FEBRUARY 2015

1. Introduction/Overview

1.1 The UK Space Agency conducted a public consultation on a draft National Strategy for Space Environments and Human Spaceflight. 'Space Environments' refers to all research conducted in space, utilising one or more condition of the space environment – for example, microgravity, radiation, extreme vacuum – or in ground-based facilities which mimic these conditions, such as drop towers simulating microgravity or Antarctic stations providing isolation. 'Human Spaceflight' here describes all human presence in space.

1.2 The draft strategy sets a national vision for work in this area; defines goals which will deliver this vision; identifies different routes to achieving these goals; and highlights key areas of UK research which will support and benefit from this strategy. The vision in the draft strategy is as follows:

> *The UK will be a recognised and valued participant in human spaceflight and space environments research – in low Earth orbit, on analogue platforms and in deep space exploration. Advancing scientific knowledge and technological capabilities as a pathway to growth will positively augment the UK economy and provide measurable societal benefits in sectors such as healthcare, communications and education.*

And the top level goals are:

- *To deliver excellent science and technology in line with UK priorities*
- *To exploit the public fascination and enthusiasm for human spaceflight to deliver education*
- *To use the interdisciplinary nature of these platforms to foster new collaborations*
- *To win contracts for UK industry and attract new investment in the UK*
- *To help prepare the UK for possible future commercial human spaceflight endeavours*

1.3 Following extensive consultation with stakeholders, and through formal Agency advisory structures (the Space Environments Working Group and the Space Exploration Advisory Committee, both comprised of independent experts from academia and industry), the public consultation sought responses on the contents of the strategy, based around the following questions:

1. Does the draft strategy offer a clear vision for the UK and provide a coherent framework for achieving this vision?
2. Are the goals in the proposed strategy appropriate and feasible?
3. Are the highlighted research areas appropriate, and do you feel any area is not covered which should be?
4. Is a proper balance achieved between academic and industrial benefits, and is the correct emphasis placed on the Agency's role and that of partners?
5. Are all relevant institutional stakeholders identified in the annex to the strategy? If not, please identify any others.
6. Do you have any other comments to make on the proposed strategy?

2. Conducting the consultation exercise

2.1 The consultation consisted of two phases: firstly, consulting directly with key stakeholders and Agency advisory groups: the Space Exploration Advisory Committee (SEAC) and the Space Environments Working Group (SEWG) (see annex 1). The draft strategy was presented to two meetings each of the SEAC and SEWG and following advice from each group, revisions were made.

2.2 Following input from stakeholders and endorsement of the draft strategy from the SEAC and the SEWG, the Agency conducted a public consultation. This was primarily promoted online and most responses were received by email. This public consultation phase would not ordinarily be necessary for an Agency strategy document of this nature, but due to this being a new and highly cross-disciplinary area for UK Space Agency activity, and one likely to elicit much public interest, it was felt that a public consultation would ensure all interested parties an opportunity to comment.

2.3 19 responses were received to the public consultation. Of these, one was deemed inadmissible. Of the 18 valid responses, the distribution of types of respondent was:

9 individuals
3 charities or social enterprises
2 large businesses (over 250 staff)
1 medium business (10 to 250 staff)
1 micro business (up to 9 staff)
1 Other – University
1 Other – UK Research Council Laboratory

Of those 9 individuals, 5 could be described as active academic researchers, the remaining 4 as persons with some professional interest in the space sector. 17 of the 18 valid responses were received by email; 1 was received by post.

The majority of respondents used the designated response form and responded to the specific questions which had been asked in the consultation document. Some respondents provided additional comment, or used an alternative format – these responses were also considered and are summarised and addressed under paragraph 3.7 and 3.8 below.

3. Government Response

The responses received to the consultation are summarised below, organised according to the consultation questions. The Government's response to each is given in turn. Those responses which did not follow the standard question format are addressed under sections 3.7 and 3.8.

3.1 Question 1: Does the draft strategy offer a clear vision for the UK and provide a coherent framework for achieving this vision?

Analysis of responses

The responses are mostly positive – all answers given are either a simple 'yes,' or a 'yes' followed by additional matters recommended for inclusion. Several respondents are pleased by the reference to the international context and the work of the International Space Exploration Coordination Group (ISECG), in particular the Global Exploration Roadmap (GER).

Some respondents are positive about the direction of the strategy but request more detail on how the strategy will be delivered, and some feel that a more ambitious strategy is necessary – for example by giving a more explicit focus on longer-term space exploration beyond Earth orbit; by committing to ESA programmes beyond the current cycle; by increasing the national human spaceflight budget and by ensuring more UK astronauts after Tim Peake. One respondent proposes the establishment of a UK astronaut corps.

One respondent makes an important point regarding the definition of 'space environments' and suggests that the usage in the current document will be confusing to the space community in the UK and internationally (because 'traditionally' the term 'space environment' has a discrete meaning, relating to study of plasma and micro-particle environments, how these interact with spacecraft and the study of space weather.)

One respondent suggests that the notion of the UK being a 'valued participant' needs to be clarified – i.e. valued by whom, and measured in what terms?

Government Response

Considering the range of responses, it is reasonable to assert that the strategy does indeed offer a clear vision for the UK and provide a coherent framework for achieving this vision. The UK will continue to participate in ISECG and use the ISECG products such as the Global Exploration Roadmap to inform its planning; these are recognised as important tools in a field requiring significant international cooperation.

Regarding details on delivery: the Agency will develop a delivery plan in 2015. The purpose of the strategy is to give an overarching framework; the delivery plan will explain the practical measures proposed by the Agency to implement the strategy.

Regarding the ambition of the document, the Agency is pleased to note the enthusiasm of stakeholders and the optimism generated by the UK's entry to the field of human space exploration. The vision statement includes direct reference to deep space exploration, and the Agency considers this a clear statement of significant ambition. The Agency remains mindful that ambition must ever be tempered by

realism, and new activities should be developed in a gradual manner – this is why an activity to consider post-ISS options is proposed in section 3.7 of the strategy. For clarity, the strategy will be amended to state that options for beyond Earth orbit exploration will be included as part of the post-ISS options analysis.

Regarding the use of the term 'space environments' the Agency recognises the potential difficulty with this term, but has adopted it as it has emerged from the research community (what is sometimes called the 'microgravity research' community – itself a misnomer.) Alternatives will be considered, but the Agency is wary of reverting to the limited term 'microgravity,' or trying to impose a new designation on a nascent community already self-identifying as 'space environments.'

The Agency agrees that the strategy should be amended to include a definition of how the UK will be a 'valued participant'. The intention is for the UK to be valued by international partners and recognised by other nations and space agencies as having expertise and capabilities necessary to support work in space environments and human spaceflight; this will be made clear.

3.2 Question 2: Are the goals in the proposed strategy appropriate and feasible?

Analysis of responses

Respondents are broadly supportive of the goals in the document. Some respondents accept the validity of all the goals, but are more supportive of some goals than others – as might be expected when receiving feedback from a range of people with different interests.

The need to consider deep space exploration is once again raised, with the suggestion that this be somehow incorporated as an additional goal, or that 'exploration-led' human spaceflight aspects be explicitly included in the goals.

Three respondents highlight the importance of further investment in human spaceflight activities to deliver the goals. In particular, the fifth goal, 'To help prepare the UK for possible future commercial human spaceflight endeavours,' requires expertise the UK does not currently have for human-rating hardware. Such expertise can only be attracted to the UK if there is confidence in long-term investment in human spaceflight programmes.

One respondent suggests that the goals be prioritised, and one that they need to be linked to clear measures and milestones.

Government Response

The Agency is pleased to note that the goals are accepted as appropriate and feasible by nearly all respondents. Regarding deep space exploration, the Agency considers that the amendments to the document proposed in response to question 1 above will be sufficient to cover this issue. Deep space exploration is not a goal in itself, but will inevitably enable some of the goals already listed; whilst conversely pursuit of these goals will also prepare the way for deep space exploration. It might also be noted that the Agency already has an exploration strategy focused on robotic exploration and this is not covered in the current exercise.

Regarding preparing the UK for possible future commercial human spaceflight endeavours: there is clearly capability elsewhere in Europe, but not in the UK, for

delivering human-rated items. The strategy therefore intentionally focusses on other areas – having an attractive regulatory regime and developing our extant national expertise in space medicine and human health. Seeking to expand the UK capabilities beyond this will depend upon significant, longer-term investment by the UK government; this remains under consideration by the Agency.

Regarding prioritisation of goals: this is deliberately avoided. All the goals are inter-dependent and prioritising one over another would both be illogical and risk unnecessarily causing divisions in what is a well-integrated sector. The Agency agrees that goals should be linked to specific milestones and targets; this detail will be in the delivery plan rather than the strategy.

3.3 Question 3: Are the highlighted research areas appropriate, and do you feel any area is not covered which should be?

Analysis of responses

Three respondents propose that planetary science also be included – this discipline will benefit significantly from future human exploration beyond Earth orbit, and is an area of considerable UK expertise.

Two respondents question whether astrobiology/astrochemistry should be included, as the immediate socio-economic benefits are less clear than for, say, medical research – one respondent stating that 'research for research's sake should be avoided'. One respondent questions whether 'health' should be explicitly included alongside biomedicine. One respondent urges an emphasis on space plasma research, noting that this often falls 'in a grey area' between Research Council remits.

Government Response

It must be born in mind that the science research itself is not funded by the Agency. In line with all other space programmes in the UK, the Agency funds the space infrastructure, but other bodies – most significantly, but not exclusively, the UK Research Councils – fund scientific exploitation. The goals included therefore reflect existing Research Council strategies. The Agency rejects the notion that only research with direct application or more 'immediate' benefits should be supported. A healthy research base, as evidenced by the breadth and excellence of research supported by the Research Councils, encompasses everything from fundamental or 'blue-skies' research to industrial and applications-driven R&D.

The Agency acknowledges that there is sometimes a tension when a given research area is not a high priority for the relevant funders, but has application for future space exploration goals. For example, plasma physics in the space environment often falls between STFC and EPSRC priorities; space medicine is unlikely to win the support of the MRC unless it makes significant impact on the ground – but both areas may be crucial for future human exploration missions whilst also delivering a degree of impact on the ground (maybe 'very good impact' but falling short of 'excellent impact'). The Agency will consider how to manage funding for space environments research, to maximise the benefits from investment in the space infrastructure whilst preparing for longer-term exploration goals.

Planetary science is not included in this strategy because space environments facilities are not seen to offer great advantages for planetary science; rather, as respondents note, it is the longer-term human missions beyond Earth orbit which will offer new opportunities. The gains to planetary science will therefore be considered when assessing the UK's involvement in post-ISS programmes, and the Agency will continue to consider planetary science one of the major drivers for exploration.

The Agency recognises the strength of the planetary science research community in the UK, and has shown extensive support for planetary science missions through its space science programme and its Aurora exploration programme.

3.4 Question 4: Is a proper balance achieved between academic and industrial benefits, and is the correct emphasis placed on the Agency's role and that of partners?

Analysis of responses

All responses are broadly positive. A few respondents make comment beyond simply supporting the draft strategy: two emphasise the interdisciplinary nature of the sector and stress the need for the Agency to therefore take a decisive lead. Specifically, one respondent notes: 'Section 4.1 states "Due to dependence on other bodies, [the Strategy's] content is subject to their *approval* [my italics]. I think this would be a mistake, and would suggest replacing "approval" by "consultation" or "advice".

Two respondents agree with the general balance, but would welcome more emphasis on industrial benefits. One of these suggests a stronger focus on knowledge exchange and promoting the use of academic knowledge in industry, stating that the Agency can have a key role in fostering this exchange.

Government Response

The Agency notes that the highly interdisciplinary nature of this field leads to challenges in balancing the views of its partners. Providing leadership on space matters which cross boundaries is part of the Agency's *raison d'etre*. It agrees with the proposal to modify the text regarding *approval* of other bodies to *consultation* – but is clear that extensive consultation is indeed necessary and will be maintained.

The desire for greater focus on industrial benefits is noted. One obstacle to greater specificity in this first version of the strategy is that, due to the UK's new involvement in these programmes, where exactly industrial benefits will transpire remains to be seen (contra science, which has to date been a more significant driver). Put simply: it will take industry slightly longer to realise the opportunities of this new sector than it will academia which has been actively pushing for UK space environments and human spaceflight for a number of years. Directed activities to address this will be detailed in the delivery plan.

3.5 Question 5: Are all relevant institutional stakeholders identified in the annex to the strategy? If not, please identify any others.

Analysis of responses

It was proposed that the following also be consulted:

Department of Trade and Industry
Royal Society
Royal Aeronautical Engineering Society
British Interplanetary Society
British Antarctic Survey
UKSEDS
Natural Environment Research Council

Government Response

All of these organisations were invited to respond, with the exception of DTI, which no longer exists, and NERC, which informally told the Agency that it did not have sufficient interest in this area to consider any involvement.

3.6 Question 6: Do you have any other comments to make on the proposed strategy?

Analysis of responses

Responses to this question express general support and congratulate the Agency on the development of the strategy; urge greater consideration of deep space exploration; underline the importance of the Agency representing UK science on the international stage and note the importance of a good communications plan.

One response to this question argues for the importance of suborbital flights as research platforms; this is considered below (in section 3.7), alongside other similar points.

Government Response

The Agency is pleased to note that the draft has been mostly well-received and notes the comments.

3.7 Other significant comments

Analysis of responses

Two responses are generally supportive of the draft strategy, but make arguments for greater inclusion of suborbital spaceflight as a mechanism for realising the strategy's aims. This is through both a) developing UK spaceplane technology and b) the establishment of a UK spaceport, and the associated presence of an 'anchor tenant' at the spaceport. Respondents note that greater reference must be made in this strategy to recent government initiatives and announcements on this subject.

It is stated that suborbital spaceflight can help deliver all of the goals in the strategy. A UK spaceport would create opportunities for research, innovation, industrial growth and education. In addition to the direct opportunities created by having domestic suborbital spaceflight capability, respondents state that this would have a catalysing effect on the whole sector. Even if the market initially relied upon satellite launches and tourism, such launches would also have capacity for academic research and industrial R&D, in line with the aspirations of the strategy.

A specific recommendation is made to include spaceplane development as a fourth option for delivery in the strategy (separate from option 2: procuring space on existing commercial platforms).

It is also suggested that spaceports be mentioned in this section of the strategy. All three of the options outlined in the draft strategy would be enhanced by the establishment of a UK spaceport: 1. It would prove attractive to other nations interested in bilateral missions; 2. It would provide frequent access to space for industry, government and academia; 3. It would enable new ESA activities to be located in the UK. Having domestic spaceflight capability will also extend the value chain in the UK – where the draft strategy is currently focused on research and downstream or spin-out benefits, more direct industrial opportunities would be created.

One response is supportive of the broad aims of the draft strategy, but calls for significant increase in ambition, and accordingly in funding too. A proposal is made for a UK Astronaut Corps, similar to that of Canada, and for bilateral agreements with NASA – noting that continued cooperation with ESA limits the UK's flexibility, as ESA programmes will always be shaped by the wishes of other member states, which may not be aligned to the UK's.

It is stated, as with several of the responses in sections 3.1-3.6 above, that the UK ought to focus on human exploration beyond Earth orbit and that the draft strategy does not take this properly into account; one effect of the emphasis on 'space environment research and practical economic returns' is considered to be that the importance of human spaceflight for exploration and education is excluded from the strategy. The importance of the UK taking a long view is emphasised.

<u>Government Response</u>

The Agency notes that given recent work investigating the feasibility of commercial spaceplane operations from the UK – in terms of regulation; the *UK Government Review of Commercial Spaceplane Certification and Operations* and the consultation *Supporting Commercial Spaceplane Operations in the UK*[1] – such developments should be more explicitly addressed in the strategy. These areas are not the focus of the strategy, but they will undoubtedly influence the future of space environments research and human spaceflight activities in the UK, and so they will be expanded upon in the final document whilst remaining mindful of the strategy's scope.

It should, however, be noted concerning the potential UK spaceport: 1. there is no firm commitment to the development of a spaceport and it remains under consideration, where responses to the consultation mentioned above are currently being reviewed and the Government response will be published in due course; 2. its benefits in delivering the goals of the draft strategy, above and beyond what is offered by existing infrastructure, are unclear (these benefits depend on many factors including immature markets, a definition of the exact facilities the spaceport will include, and the range of services offered by operators); however initial assessment indicates sizeable potential returns to the UK economy.

It is not considered appropriate to include spaceplane development as a fourth route to delivering access to space – such an undertaking would be a significant project of

[1] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/360448/spaceport-consultation.pdf

relevance not just for space environments and human spaceflight, but for the space sector as a whole. In other words, this is an issue beyond the remit of the draft strategy under discussion, which focuses quite deliberately on concrete immediate and near-term opportunities. Paragraph 3.7 of the draft strategy explicitly identifies the need to consider alternative options for future space access; reference to the larger issue of spaceplane development will be included here instead.

Increasing the ambition of the strategy will be considered in subsequent updates, depending on analysis of the success of the UK's initial involvement in the ISS and ELIPS programmes. The Agency considers establishment of a UK astronaut corps is at best premature – membership of ESA and the excellent services of the ESA Astronaut Centre, as exemplified by their support for Tim Peake, are considered the best option at present.

Regarding the perceived inflexibility of ESA programmes: the benefits of cooperating with other European nations through ESA far outweigh the costs in terms of programmatic issues. The Agency considers some degree of compromise an inevitable part of international cooperation – this is simply the reality of collaboration. Joining directly an ongoing programme which has some heritage and momentum of its own allows the UK to 'leapfrog' the costly process of establishing a programme from scratch and become an active player in human spaceflight much quicker than going it alone. The proposed alternative of increasing cooperation with NASA is misleading: in a bilateral with NASA, the UK would be the junior partner by some distance and thus subject to the programmatic whims of NASA. By contrast, in ESA programmes each member state has an equal voice.

The recurrent theme of human space exploration beyond Earth orbit must of course be taken seriously, but the Agency disagrees that focussing on immediate benefits excludes this, and does not recognise a dichotomy of exploration versus economic or social benefits. This is why, in the 'Vision' statement, the first sentence of the draft strategy directly references deep space exploration; the second notes the benefits to the economy and to society.

3.8 Input from 'Pupils 2 Parliament'

An organisation called Pupils 2 Parliament, which aims to give pupils at school a voice in government decision-making through facilitating responses to consultation exercises, submitted a report in response to the consultation. This report gives the views of 156 pupils aged 9 to 13 at four schools in Oxfordshire, Berkshire and Middlesex. This response, naturally, contains a diversity of opinion and many interesting views, which did not directly follow the format of the consultation questions, and therefore is considered here separately from the other responses.

<u>Analysis of response</u>

60% of children said they were interested in space, 40% that they were not particularly interested. Those who were interested reported a whole range of different aspects of space that they found interesting, most of which we would classify as in the realm of astronomy or planetary science.

Most of the children (64%) agreed that the UK Space Agency should spend time and money on promoting Tim Peake's flight – though a significant minority (36%) disagreed with this. Whilst there was some enthusiasm for astronaut flights and Tim Peake in particular, with some children saying it would be inspirational and

encourage interest in science and space, there was also some notable scepticism, both of the mission itself: 'They thought it wasn't enough to say that he was the first British astronaut there, or that lots of people would be interested in hearing about this. Being an astronaut 'has been done'' and of government motivations: "One was concerned that money might be spent trying to get the public interested in space just to be able to say that spending more on space looks as if it is in line with what people are interested in".

The children voted on different areas the government could invest in, and the priority according to the children is clearly to invest in scientific research which is likely to bring results useful to people generally, for example in health and medical research, particularly research that can really only be done in space. From the children's votes, this should be a wide range of scientific experiments, rather than doing fewer experiments in more depth or repeating them in space to double check their results. The next priority is investing in future human passenger space flight. The other elements of the plan got support from fewer than half the children, though using space work to get more children interested in science subjects and science careers came close to being supported by half the children.

Many children agreed that space should enable science that is 'useful as well as interesting' and that wanted to see 'more science of all sorts done, not just space science, and therefore space work should always try to lead to wider science.'

Government Response

The Agency welcomes young people engaging seriously with its decisions and providing thoughtful feedback. Some of these responses are encouraging and, taken as a whole, can be taken as conditionally supportive of the draft strategy. It should be noted that the children's support for 'useful' research and research with clear benefits on Earth mirrors the draft strategy, which has a clear emphasis on terrestrial benefits. Also, the desire to see 'more science of all sorts done, not just space science' is well aligned to the goals of the draft strategy – the only space science included in the highlighted research areas is astrobiology/astrochemistry; the other three highlighted areas are not 'space-specific' disciplines.

Nonetheless there are lessons which need to be taken on board, and the Agency notes the challenge in reaching young people and demonstrating the value of research in space. The much-vaunted 'inspiration' value of space cannot be taken for granted and novel ways must be sought of engagement and outreach. Even among those interested in space, many reported that they had other, more important interests. The Agency has a significant astronaut flight education programme; this will be maintained and the Agency is considering extending this activity to capitalise on the heritage of Tim Peake's mission. The Agency will also ensure that UK scientists support further outreach activities, as evidence suggests that outreach grounded in 'real science' is far more effective.

4. Conclusion

4.1 On the whole, the draft strategy presents a coherent framework which most stakeholders support. The UK's new involvement in space environments and human spaceflight presents opportunities which the government, industry and academia can exploit, and the proposed strategy gives a clear direction, purpose and framework for the UK's continued activity in these areas.

4.2 There are however some issues to be addressed by the Agency. Key issues to emerge from the consultation exercise can be grouped into four themes:

- The challenges of academic funding
  - Research which falls between remits
  - Research in novel areas
- The importance of future exploration beyond Earth orbit
- The challenges for industry
  - Lack of heritage in upstream human spaceflight
  - Uncertainty of long term commitment
- The opportunities presented by suborbital spaceflight and a UK spaceport

Some of the issues raised can be addressed directly in an updated strategy document; some will be taken forwarded as separate actions by the Agency.

4.3 Regarding the challenges of academic funding: the Agency will consider the establishment of a funding line for scientific research in space environments which i) has clear and terrestrial benefits and ii) prepares for future human space exploration. It will not consider expanding its remit to fund science which might ordinarily be supported by Research Councils; that a proposed science activity occurs in space is not sufficient to warrant Agency support. Close coordination with the Research Councils, and providing advice and guidance on science which uses space environments will continue.

4.4 Regarding the importance of future exploration destinations beyond Earth orbit: the Agency recognises the importance of planning for deep space exploration. For this reason, it is a member of the International Space Exploration Coordination Group (ISECG), which produces the *Global Exploration Roadmap.* It will continue its involvement in ISECG. For the national strategy, deep space exploration is acknowledged as a longer term goal, but the Agency considers the focus on benefits in the near to medium term appropriate – discussion of benefits in the long term will necessarily be speculative.

4.5 Regarding the challenges for industry: the Agency will work more closely with its partners in other government bodies (e.g. Innovate UK and the Catapult centres) to pursue downstream applications. A longer term commitment to the ISS is currently under consideration.

4.6 The opportunities presented by suborbital spaceflight and a UK spaceport: this issue will be given greater prominence in the final version of the

strategy. It will be considered a related issue which may enhance delivery of some of the strategy's goals, rather than comprising any goals in and of itself.

5. Next Steps

5.1 The draft strategy will be amended to reflect the points above and published alongside the present document. The strategy will be distributed to stakeholders and presented at relevant events and conferences.

5.2 A Delivery Plan will be drawn up in the first half of 2015.

5.3 The UK's continued involvement in the ESA ISS programme was confirmed at the ESA Council of Ministers in December 2014, with UK committing to the programme until 2020. Further decisions on both ISS and ELIPS subscriptions will be made at the following Council of Ministers, expected in late 2016. The strategy will inform these decisions.

5.4 The strategy will be reviewed and updated in 2016.

6. Contact details

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Annex 1

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