

**RESPONSES TO SPECIFIC QUESTIONS OF THE
CAA SPACEPORT CONSULTATION**

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FAO

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1 Introduction

This document provides concise responses to the eleven specific questions presented in the Consultation call document [1]. This response has been produced from material and considerations of all team members of Catena Space Ltd., a UK-based space business and technology consultancy company. For each question, we include and highlight the text of the call document question, followed by the response text.

2 Consultation Questions

Q1

Do you agree with the CAA's high-level recommendation that, if a decision were taken to proceed, sub-orbital operations should preferably commence, either on a permanent or a temporary basis, from one (or more) of the following:

- an existing EASA-certificated aerodrome;*
- an existing UK CAA-licensed aerodrome; and/or*
- an existing UK military aerodrome, subject to approval from the MOD.*

YES

We agree with the high-level recommendation regarding re-use of an existing facility. This recommendation is naturally aligned with the assumption of only operating vehicles that are predominantly spaceplanes. This includes the emergent spaceplane concepts, as well as secondary vehicles (rockets) air-launched from other (non-space) platforms. We understand therefore that this explicitly excludes wingless and vertically launched systems.

There is demonstrable market need for the latter class of systems which are not apparently to be considered in this consultation (although they are mentioned in CAP 1198, the Summary & Conclusions to the UK government Review of commercial spaceplane certification and Operations, [2]). The UK is host to a vibrant and growing small satellite industry, who are required to seek launches for payload in the 1-150kg range entirely outside of Europe, at considerable commercial risk. Further, a small but growing community exists of scientists and researchers interested in making use of short duration exposure to the microgravity environment. Such activity will be stimulated by the UK's subscription to the ESA ELIPS (European Life and Physical Sciences) programme.

Short duration exposure to microgravity conditions can be effectively met by vertically launched suborbital, recoverable or 'sounding' rockets which could be launched from the UK. A UK spaceport could and should cater to this need. Restriction of the proposed spaceport to sites focussed upon aviation and technology associated with spaceplanes advances its development only with regard to a perceived market need for spaceplanes. While a potentially large market, spaceplanes remain commercially unproven.

Thus the recommendation should consider that making use of an existing facility is recommended on immediate economic and planning grounds, but that the facility (or facilities) should cater to a range of potential users and business models. As discussed in Question 3 - a greenfield site may best be able to meet this range of service requirements, whereas the current site candidates cannot.

Q2

Do you agree that in order to make maximum use of existing infrastructure, the location should preferably still be active but at a low level of aircraft movements and should have existing and appropriate ground infrastructure/facilities and service provision?

YES

There are clear advantages to adapting a facility that is still operational, with particular regard to the physical integrity of the infrastructure, the speed at which spaceport activities can be ramped up, and in reducing the overall capital requirements at the outset. However this response implicitly assumes that business will be focused on spaceplanes for space tourism and closely related activities. Reports such as Space-CITI by SSTL [3] indicate that earlier, less speculative revenue streams such as suborbital sounding rockets may be an essential part of a robust business case.

Q3

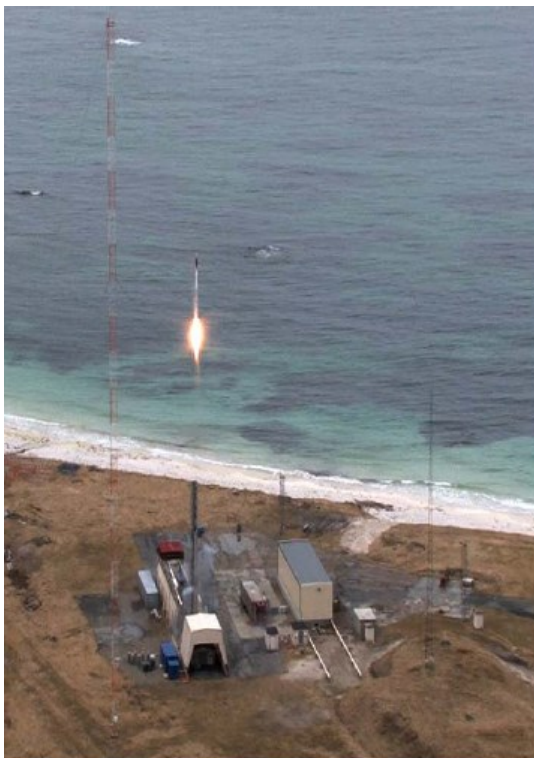
Do you agree that greenfield sites should not be considered?

NO

There are business cases for spaceport activity that are not readily supported by the candidate sites. As such, there might be a case for considering a site that would include or overfly (or partially include or fall adjacent to) greenfield sites. An outright exclusion of such sites would limit opportunities for future spaceport business scope and growth.

At the least, a greenfield site able to cater for the modest requirements of small vertically launched vehicles (suborbital or orbital) needs to be considered. Small vertical launch systems require, at minimum, a gantry and heat resistant launch pad, a control building and a payload / launcher integration building, plus some storage for propellants. A coastal site is recommended.

These may be considerably more cost effective to implement directly, due to very modest infrastructure requirements, rather than as modifications to existing airports (especially if runway extension is required). A green field site may be an extension to an existing airport, subject to range safety and downrange limitations, or in the specific case of vertical launch to orbit (small satellite launch)



Coastal launch sites for vertical launch showing typical infrastructure
(Left - Andoya Rocket Range – courtesy Nammo, and Right - Vandenberg AFB, courtesy USAF)

Q4

Do you agree with CAA's analysis identifying the criteria to be considered in identifying a permanent location for a UK spaceport? If not, please explain why.

PARTLY

We consider that the analysis in identifying the criteria is in itself sound, but has inherited assumptions about the real market opportunity to be supported by the site. For example, flexibility of business model or flight vehicle concepts (to support e.g. point-to-point suborbital flight, or wingless small launchers) has not apparently been factored into the criteria. A highly ranked site for a perceived immediate opportunity may prove less effective over time as the markets evolve. This reduces to a 'scope for growth' or functional/business pivot issue.

In particular we note that the market for suborbital spaceplanes is both unproven and largely driven by technology which is at present restricted to the United States. There is substantial risk in two quite likely scenarios:

- (i) spaceplane business may fail to materialise on the scale predicted, and
- (ii) spaceplane business may remain outside of the UK – indeed Europe - well beyond the expected operational date of 2018 for the UK spaceport.

We recognise that this might not have been a priority for the consultation to date, but in assessing the overall economic impact of the considerable investment in a new UK spaceport ensuring a site or sites can take advantage of known current markets (in particular the UK production of small and nanosatellites) and future, uncertain markets would seem to be a rational course to pursue.

In addition to serving needs for current small satellite builders, a further use case for such infrastructure that is not evident from the requirements presented may be for test flights of the Skylon vehicle, a concept already receiving UK public financial support. Given the welcomed support to Skylon and ELIPS, the notional 'opportunity jigsaw' appears to have some pieces missing.

More than one site may need to be selected to ensure that sufficient business is attracted to or stimulated, or supported in the UK, in turn to justify government efforts in creating a favourable legislative environment.

Q5

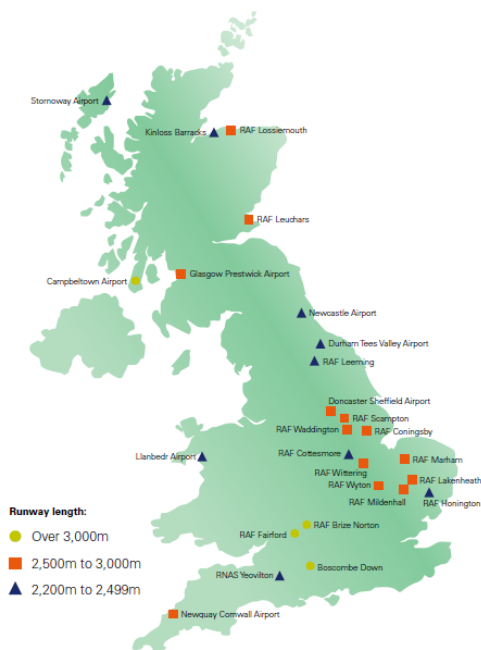
Do you think there are any other criteria that should also be taken into consideration? If so, please explain why.

YES

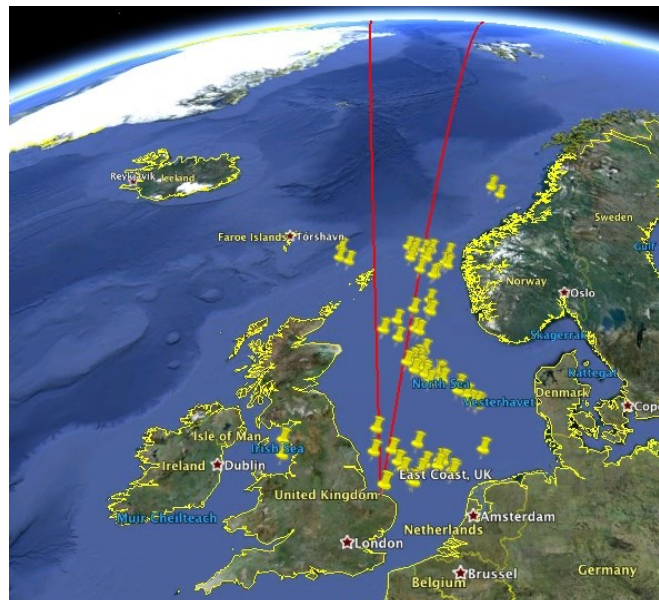
Additional criteria should be considered that relate to each site's potential for associated economic development and job creation. What is their respective ability to support additional jobs and local industry? Is there regional capacity to grow related industries? Can each site equally access appropriate skills, training and R&D capabilities?

We note that there may be a potential conflict between the low population density desirable for safety, and the level of population required to support a growing economy and the provide coverage of the necessary skills. As such, the main criterion to include is the holistic economic viability of any given site, and assessment of the uncertainties in this viability - firstly with time (with respect to the intended operational schedule and market readiness), but also with regional, economic, technological, export control, security, and customer-driven factors.

A site able to support launch of small satellites to orbit will need a clear downrange in a north or approximately northern direction (shown) to allow for a polar or near polar trajectory which is required by the majority of such satellites. The UK could host many such sites as shown by a list of potential military and civil airfields taken from CAP 1189 [9].



Potential spaceports
CAP 1189, p. 189




Safety trace for polar launch showing
North Sea oil rig locations

Q6

Do you agree that these are relevant criteria? What weight should be attached to them?

YES

All the criteria identified are relevant. Our proposed ranking appears in table form below.

<p>Highest priority</p>  <p>Lowest priority</p>	Operational (3000m minimum runway length)
	Safety: remote from general population, protected by segregated airspace, flight operations zone over water – and ideally downrange allowing suborbital or preferably polar orbital flight.
	Economic – a range of economic factors exist including
	- Deliverability (as a functional, profitable site)
	- Potential for growth of space or aerospace sector, wider supply chain especially in local area
	- Potential to promote high level skills
	- Potential to stimulate spin off activities, notably tourism, scientific research, space propulsion testing, training and education
	- Potential to advance science and innovation through support to a wide range for access to space activities.
	- Synergy or support to existing economic usage of spaceport location
	Meteorological: although crosswind, cloud and icing factors may both affect operability and the passenger experience, a limited number of flights are likely (summer months) in the near term, reducing the weighting of this. Also unmanned suborbital, or orbital rockets which do not require a runway landing are more suitable for launching in a wide range of conditions.
	Site Security: can the site be easily secured from unintentional trespasses / activists or terrorists
	Environmental: spaceplanes operate in limited numbers and generally utilise low environmental impact or 'green' propellants. Therefore this criterion should have a relatively low priority.
	Accessibility: the site must be accessible by its workforce, to transport vehicles and support equipment, and by potential passengers and / or tourists - a low priority noting that very few places in the UK are truly remote requiring many days and / or high cost to access.

Proposed Ranking of Site Criteria

Q7

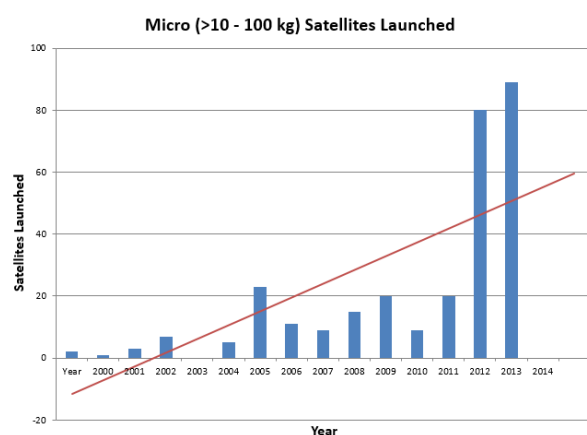
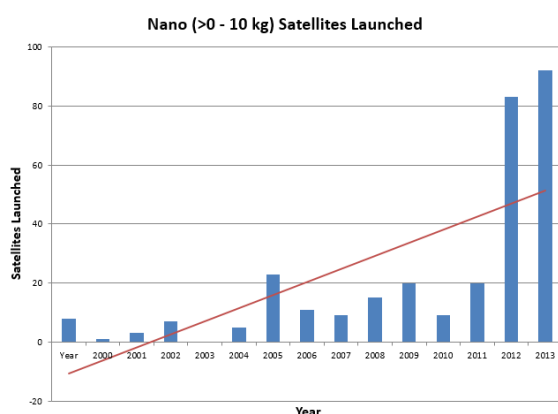
If more than one location closely meets the essential operating criteria, safety, meteorological, environmental and economic criteria, do you agree that we should also consider factors around the contribution to local and national growth? If so, what weight should be given to these factors?

YES

The government is driving the space sector to create jobs and drive economic growth (through the supply chain, services, and tourism), with a clear goal identified in the Innovation and Growth Strategy [4] to increase the workforce to 100,000 people. Potential job creation (ideally locally or regionally) should therefore be a criterion applied to candidate site locations.

The potential revenue that the Spaceport can capture is an important factor in its location. While all sites may have ostensibly the same potential in a given market, how long a revenue stream will take to materialise and how robust it is will determine the viability of the business plan. Note, for example:

- The SSTL lead Space CITI study which is summarised in the Market Analysis section of CAP 1198([2] p. 27) indicated a potential UK demand for space tourism flights of up to US\$19M in year 1, rising to \$24M in year 3 with the potential for \$65M by year 10. These figures are very modest compared to the potential investment required in implementing a spaceport e.g. lengthening runways, adding propellant farms, new passenger processing facilities etc. Further the UK demand is contingent upon a healthy and growing space tourism industry starting up in the US and seeking to expand its market abroad.
- In contrast, the same SSTL study (although less well publicised) noted the rapidly growing small satellite launch market, summarised in the figures below:



Vertical launch to orbit market growth

Nanosatellite launch prices vary between \$150k and \$0.5M suggesting a market in excess of \$10M in 2013 alone, and potentially much larger by 2018. Microsatellite launch costs vary between \$1 and \$5M again pointing towards a substantial current market. The market share that could be captured by a new entrant, the rate of growth and the range of accessible orbits, must all be explored but the potential market value which could be facilitated by a spaceport is very significant. This would be some national business and a very large proportion of export sales / international business.

The selected location has to be accessible and attractive internationally to capture European business and suppliers, and to attract US-based spaceplane operators. Prompt delivery of an operational site will help attract operators before they face expansion or multiple site operations in the US.

In considering local and national growth, per the question and directly related to the IGS [4], this potential should not be ignored. It is questionable whether the export control restrictions on US operator technology would permit much growth as measured by return to the UK economy, since all spaceplane equipment and much of the ground support (maintenance) would be owned and operated by foreign operators (the 'wet lease' approach) thus limited UK revenue to support services.

Q8

Do you agree with the CAA's analysis and strong recommendation that until there is a better understanding of sub-orbital spaceplane safety performance, spaceplane operations should only take place in areas of low population density and the resulting view that only a coastal location is suitable to protect the uninvolved general public?

YES

This follows closely the principles adopted by the FAA. Coastal sites are also more likely to facilitate operations for orbital launch and suborbital launch and recovery. However, clustering of supply chain and space technology businesses should be fostered. Both start-ups and more established companies will need to be attracted, and transport links will have some influence. These should not divert focus from the coastal factor, but may assist in selecting between multiple coastal candidates.

Q9

What are your views on the CAA's shortlist of eight potential sites?

No particular comments are offered on the current shortlist; see however our response to Q10, over.

Q10

Are there any locations on the CAA's shortlist which you consider should be disregarded?

NO

We consider that there are sites in the current shortlist that are notably less suitable prospects than others. However, given an expectation of the robust application of appropriately weighted criteria (in particular economic ones based on current and realistically projected launch business), there is not a reason to avoid applying the criteria fully to the set of candidate sites. This may be important should the set of criteria be extended and/or reprioritised, especially in recognising that no site will be perfect. The potential for selecting more than one site to cater to different launch business streams in particular should be kept open.

Q11

Are there any additional locations that you consider should be on the CAA's short list?

(RAF) Dounreay, with an extant aerodrome, matches most of the identified criteria and also provides good sky access northwards, which is important for some market opportunities. While the aerodrome and runway are no longer active, they were operational until the 1990s. We expect that it has been excluded from consideration so far on the basis of its relatively short runway (1.75km). Runway extension to 3km would be costly but feasible (bounded by the A836 and the North Sea), while the site offers strong potential for vertical launch. No site in the list of proposed candidates is clearly suitable for small orbital launch, but several could support both manned and unmanned (vertical rocket-based) suborbital launch.



RAF Dounreay (Imagery from Landsat, via Google). Yellow line indicates extent of a 3km runway for comparison with extant infrastructure.

3 Further Considerations

In addition to the consultation questions, if the spaceport operations and business model is to be limited to spaceplane activities in the near-term, and as such highly dependent upon a US vehicle/company flying from the UK spaceport, then some specific questions to be directed to possible operators would be relevant to the site selection exercise. These might include, for example:

- What is the overall campaign duration/ (minimum length, guaranteed number of years, etc.)
- What levels of staffing are anticipated to conduct business at the spaceport?
- Flight operations are likely to be seasonal. How do the staff, equipment, and vehicle presence and activities vary? Are there significant 'off' periods?
- How is supporting equipment to be transported?
- What is the required level of secrecy/security for flight operations?
- Does the vehicle require a dedicated hangar? How many vehicles would be stationed at the spaceport?
- Is a backup landing site required (within a specific range)?
- Are non-flight aspects of the business model (e.g. 'tourism' around the spaceport, experience days, tourist 'training' such as centrifuges and aerobatic flights) important enough to affect site decisions for the principal (flight) aspect?
- Has the operator fully explored the support it can expect from the US government with respect to exporting and operating its equipment internationally, and tested the validity of the 'wet lease' model?

Finally, we recommend that existing spaceports in Europe, in particular Andoya Rocket Range (Norway) and ESRANGE / Kiruna (Sweden) be evaluated as models to demonstrate the potential for low cost / modest infrastructure spaceports to support vertically launched rockets, both suborbital and orbital.

4 References

- [1] Supporting Commercial Spaceplane Operations in the UK, Consultation on criteria to determine the location of a UK spaceport, Call document (DfT, BIS, UKSA, CAA)
- [2] CAP 1198:2014, the Summary and Conclusions to the UK Government Review of Commercial Spaceplane Certification and Operations
- [3] Space CITI report 2013: UK Launch the business case for a UK Spaceport, SSTL.
- [4] Space Innovation and Growth Strategy 2014-2030, Space Growth Action Plan
[https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/298362/igs-action-plan.pdf]
- [5] FuturIST: Future Infrastructure for Space Transportation, International Space University, 2008. [https://isulibrary.isunet.edu/opac/doc_num.php?explnum_id=91]
- [6] Seedhouse, Erik. (2008) Tourists in Space: A Practical Guide, Springer-Praxis, Chichester, UK. ISBN: 978-0-387-74643-2.
- [7] Spaceport Master Planning: Principles and Precedents, C. M. Adams and G. Petrov, Space 2006, AIAA 2006-7325
[<http://spacearchitect.org/pubs/AIAA-2006-7325.pdf>]
- [8] Space Tourism – How It Will Change The World, Acceltheon Partners, 2008.
[http://www.acceltheon.com/files/Acceltheon_Space_Tourism.pdf]
- [9] CAP 1189: 2014, the UK Government Review of Commercial Spaceplane Certification and Operations – Full report.

"Creating multiple sources of revenue is paramount to the financial health of the spaceport. These revenue streams may include products and services as well as space and terrestrial tourism opportunities. As with any business care should be taken in assessing the financial risks and liability to establish appropriate contingency plans."

FuturIST [5]