UK SBAS PPP

Market Engagement Questionnaire

# Introduction

There is recognition within the UK and internationally that much critical national infrastructure is dependent in some way on Global Positioning System (GPS) and/or other Global navigation satellite system (GNSS). In October 2023, UK Govt published its new Positioning, Navigation and Timing (PNT) Policy Framework which includes a “10 Point Plan” to enhance national PNT resilience[[1]](#footnote-2). This plan includes:

*“UK SBAS: develop a proposal for a UK Precise Point Positioning Satellite-Based Augmentation System to replace the UK’s use of the European Geostationary Navigation Overlay Service, monitor GNSS and enable GNSS dependent high accuracy Position for autonomous and precision uses.”*

This point and other points in the policy framework are brought together in a statement in the new UK Space Industrial Plan published in March 2024[[2]](#footnote-3):

*“Position, Navigation and Timing (PNT): The new national PNT policy framework includes development of a proposal for a new national space-based PNT augmentation system to provide UK high precision services. This will work alongside the National Timing Centre as part of the wider UK PNT framework. The Ministry of Defence (MOD) will develop a new ‘MOD time’ to provide a system of last resort to enhance national resilience. These developments of UK’s capabilities will strengthen our capabilities and better position ourselves internationally.”*

UK Space Agency is currently developing the business case for a space-based PNT augmentation system, referred to herein as “UK SBAS”. To this end a set of potential services and associated mission requirements have been derived. These are presented at Annex A.

Respondents are invited to review these services and provide responses to the questions below, with whatever level of detail and means is considered appropriate by the respondent, considering the objective is to support development of the UK SBAS Business Case.

The questions are separated into two parts:

* ***Part A: Technical*** considers the technical feasibility and processes of developing the stated capabilities.
* ***Part B: Programmatic*** explores the projected costs and preferred commercial arrangements to deliver the capabilities.

**Note:**

It is emphasised that UK SBAS should be considered as a set of capabilities and not a single technological development. The set of services presented in Annex A are not necessarily expected to be delivered from a common platform. Potential suppliers are invited to consider the list of services and propose solutions that may include any subset of these services.

## Queries

If you have any queries in regards to providing a response to this questionnaire, please get in touch at [UKSA-SBAS-PPP@ukspaceagency.gov.uk](mailto:UKSA-SBAS-PPP@ukspaceagency.gov.uk).

We will also be hosting a webinar to explain in detail the approach to the business case and the questions asked in this questionnaire at 10am on 4th June 2024. **To attend the online webinar, please register your interest** [**here**](https://forms.office.com/Pages/ResponsePage.aspx?id=BXCsy8EC60O0l-ZJLRst2AjtKobH-jVJvQFjy-wXTZBUM1RTSkI2RklYV0JVQllMM0FFNlNBRTFaNy4u)**.**

We will be circulating a weekly FAQ document to those registered for the webinar so that all participants have access to the same level of information.

## Submitting Responses & Timescales

Responses should be submitted either as a word document or PDF.

Target for responses to Part A is **18th June 2024**

Target for responses to Part B is **28th June 2024**

These are not deadlines; later responses will be considered, but respondent’s scope to influence the programme is reduced the later submissions are received.

# UK SBAS Market Engagement Questions

Respondents are invited to present potential approaches and technical solutions to delivering some or all of the services presented at Annex A. The format of the response and level of detail is at the respondent’s discretion. The questions below may act as a framework for your response.

Please consider that the intention is to inform UKSA in their development of the formal business case for a future GNSS augmentation capability. This is not a pre-procurement questionnaire.

## Part A: Technical

### Q1: Scope of Response and Underlying Assumptions

Please provide a short summary of your potential approach. Please identify which UK SBAS mission requirements your response addresses, in full or in part.

Please state any key underlying assumptions, e.g.

“*It is assumed that two UK SBAS L1/L5 Transponders are to be provided as Government Furnished Equipment, and SBAS transponder costs, risks, etc, are excluded from the scope of this response*”.

Please identify any areas in which the respondent may be able to provide one or more critical elements to service delivery, whilst not providing a complete service, e.g. “We may be able to provide an L1/L5 SBAS transponder at a suitable location to support UK SBAS, from 2028”.

Please do not expend any effort in providing boilerplate statements of corporate experience, previous relevant projects, etc.

### Q2: Potential Additional Services

Please identify any additional services you propose for consideration within the set of future UK SBAS services. These do not have to be directly related to conventional SBAS L1/L5 signals but should be compatible with the 10 Point Plan and/or PNT component of the National Space Strategy and should focus on providing the same outcomes encompassed by the service requirements in Annex A.

### Q3: Grouping of Services and Delivery Channels

Where appropriate please state how the various services you wish to address may be grouped into sets, related by systems and platforms, e.g.:

“The conventional SBAS services (L1 OS; DFMC OS; L1 SoL; L1/L5 SoL) would be delivered as signals in space through conventional bent-pipe SBAS transponders.”

“The Time Transfer Open Service would be delivered using commercial LEO satcom spacecraft, at L-band.”

“The PPP with Integrity Service would be delivered through any channel with internet access, not as a dedicated SBAS signal in space.”

### Q4: High-Level Architecture(s)

Please provide some high-level description of your potential technical architecture (or architectures, where multiple systems/delivery channels are covered). This may be at whatever level of detail you consider to be appropriate and credible within the time available to respond to this request.

Your architecture will not be evaluated as it would be in a proposal submission. It is requested to enable UKSA to identify overlaps and gaps from multiple submissions, and to identify areas which would require particular technical and programmatic attention.

Please note that responses may be reused and/or combined with other responses without attribution. Please do not include any proprietary information, or anything which you would wish not to be shared with UK government or industrial partners in future.

### Q5: Main Technical Risks/Constraints

Where possible please identify any significant technical risks or constraints associated with your proposed solutions which should be considered by the UK SBAS programme.

## Part B: Programmatic

### Q6: Main Programmatic/Non-Technical Risks

Where possible please identify any significant programmatic and non-technical risks or constraints associated with your proposed solutions which should be considered by the UK SBAS programme.

### Q7: Development Schedule

Assuming a programme kick-off date in early 2025 please provide, for planning purposes, estimated dates (e.g. “Second half of *2028*”) to achieve:

* Initial Operational Capability (IOC) (define, if appropriate)
* Full Operational Capability (FOC) (define, if appropriate)

for any proposed service or set of services.

### Q8: Capital Expenditure

Assuming the development schedules provided in response to the questions above, please provide, for planning purposes, Rough Order of Magnitude (ROM) estimates of the capital expenditure/non-recurring costs to achieve:

* IOC
* FOC.

Please use GBP in 2024 conditions for these estimates.

Please highlight any driving assumptions. These figures are only for the business case and do not imply any form of commitment.

### Q9: Operational Expenditure

Assuming the development schedules provided in response to the questions above, please provide, for planning purposes, Rough Order of Magnitude (ROM) estimates of the operational expenditure/non-recurring costs:

* From IOC to FOC (i.e. consider all costs prior to IOC as Capex)
* From FOC onwards, assuming at least 15 years of operational service, starting at IOC.

Please use GBP in 2024 conditions for these estimates.

Please highlight any driving assumptions. These figures are only for the business case and do not imply any form of commitment.

### Q10: Delivery Model

Please provide some statement on your recommended or assumed delivery model for the approach you have presented, e.g. Government Owned, Government Operated; Government Owned, Contractor Operated; Contractor Owned, Contractor Operated; “SBAS as a Service”; etc.

Please amplify as appropriate.

Where some mix of delivery models is appropriate (e.g. part Government-owned, part Contractor-owned), please identify the envisaged separation of delivery models.

### Q11: UK Industrial Benefits

There will inevitably be some conflict between minimising the cost of any future programme and maximising the overall economic benefit (e.g. UK jobs) created to deliver such a programme. Please provide some statement of the extent to which the approach you have presented is likely to generate UK industrial benefit (upstream, i.e. in the development, deployment and operation of the proposed systems and services).

### Q12: End User Benefits

The services from a conventional SBAS primarily benefit the aviation sector. The UK SBAS programme is intended to provide wider benefits.

Where appropriate, please provide any information regarding the end user groups that are likely to benefit from the services addressed within your approach. Any supporting evidence (ideally with quantified estimates) would be much appreciated.

# Annex A: Proposed/Potential Services and Mission Requirements

The sections below define a set of mission requirements which ideally would comprise the suite of UK SBAS services. As stated above these services need not necessarily be implemented from a single platform or by a single supplier. Respondents are invited to address any subset of these services and mission requirements.

## L1 SBAS Open Service

UK SBAS shall transmit Open Service (OS) Signals in Space (SiS) at L1, compliant with ICAO SBAS Standards and Recommended Practices (SARPS) and RTCA DO-229F definitions.

The carrier frequency shall be centred around 1,575.42 MHz with at least 95% of the broadcast power contained within a 4 MHz bandwidth, with a nominal 20 MHz bandwidth.

The L1 SBAS navigation messages shall be modulated on the L1 signal in accordance with DO-229F.

The following Message Types (MT) shall be implemented in the UK SBAS L1 signal:

|  |  |
| --- | --- |
| MT | Contents |
| 0 | Do Not Use for Safety Applications |
| 1 | PRN Mask Assignments |
| 2-5 | Fast Corrections |
| 6 | Integrity Information |
| 7 | Fast Corrections Degradation Factor |
| 10 | Degradation Factor |
| 25 | Long-Term Satellite Error Corrections |
| 24 | Mixed fast Corrections/Long Term Error Corrections |
| 18 | Ionospheric Grid Point Mask |
| 26 | Ionospheric Delay Corrections |
| 9 | Geo Navigation |
| 17 | Geo Almanac |
| 27/28 | SBAS Service Area |
| 62 | Internal Test Message |
| 63 | Placeholder for Future Use |
| 12 | SBAS Network Time/UTC Parameters |

The UK SBAS L1 OS service shall cover the UK Exclusive Economic Zone (EEZ) surrounding the United Kingdom.

The UK SBAS L1 OS service shall consider the following indicative performance requirements:

|  |  |
| --- | --- |
| Performance Measure | Target |
| Horizontal Position Error 95% | < 3m |
| Vertical Position Error 95% | < 4m |
| Service Availability | >0.995 |

## L5 DFMC SBAS Services

UK SBAS shall provide a Dual-Frequency, Multi-Constellation (DFMC) SBAS services, as currently being finalised in ICAO SARPS and EUROCAE Minimum Operational Performance Standards (MOPS) document ED-259 for GPS/Galileo/SBAS dual-frequency L1/L5 airborne equipment.

UK SBAS shall transmit Signals in Space at L5, compliant with ICAO SARPS and ED-259 definitions.

The carrier frequency shall be centred around 1,176.45 MHz with at least 95% of the broadcast power contained within a 20 MHz bandwidth.

The L1 SBAS navigation messages shall be modulated on the L5 signal in-phase component in accordance with ED-259.

The following Message Types (MT) shall be implemented in the UK SBAS L5 signal:

|  |  |
| --- | --- |
| MT | Contents |
| 0 | Do Not Use for Safety Applications |
| 31 | PRN Mask Assignments |
| 34, 35, 36 | Integrity information (DFREI and DFRECI) |
| 32 | GNSS Satellite clock-ephemeris error corrections and covariance matrix |
| 39, 40 | SBAS Satellite clock-ephemeris error corrections and covariance matrix |
| 37 | Degradation parameters and DFREI scale table |
| 47 | Almanacs of SBAS satellites |
| 42 | SBAS Network Time/UTC (TBC) |
| 62 | Internal Test Message |
| 63 | Placeholder for Future Use |

The UK SBAS L5 DFMC service shall cover the UK EEZ surrounding the United Kingdom.

The UK SBAS L5 DFMC service shall consider the following indicative performance requirements (consistent with Australia/New Zealand Southern Positioning Augmentation Network (SouthPAN) DFMC indicative performance requirements):

|  |  |
| --- | --- |
| Performance Measure | Target |
| Horizontal Position Error 95% | < 1.5m |
| Vertical Position Error 95% | < 2.5m |
| Service Availability | >0.995 |

## UK SBAS Safety of Life (SoL) Service

The UK SBAS SoL Service is intended primarily for the aviation domain, although its use may be extended to any other transport domains in future. It shall be fully compatible and interoperable with EGNOS OS and SoL services.

UK SBAS will support legacy (L1-only) and DFMC SoL services.

### A: L1 SoL Service

The UK SBAS L1 SoL Service shall meet the requirements for Localizer Performance with Vertical Guidance (LPV-200) approaches and Approach with Vertical Guidance (APV-I) procedures. LPV-200 has the most demanding requirements for the L1 SoL service, to support fixed wing aircraft approaches to a 200 ft decision height and a corresponding 35 metre Vertical Alert Limit (VAL):

* with a 6 second Time to Alarm (TTA)
* integrity risk of 1 – 2 x 10-7 per approach
* continuity risk better than 1 – 8x10-6 per 15 seconds.

### B: L1/L5 DFMC SoL Service

The UK SBAS DFMC SoL Service shall support more demanding approach requirements within the UK SBAS service coverage area. The objective is to support Category I (CAT-I) precision approach operations with VAL potentially as low as 10m.

## L1/L5 SBAS Geo Ranging

*As an option*, UK SBAS may support SBAS GEO Ranging, i.e. provision of ICAO SBAS-compliant ranging signals at L1 (and optionally also L5).

Respondents potentially offering such a service are requested to outline the proposed system architecture to provide GEO ranging, with particular emphasis on the mechanism for definition of the time reference against which the Geo Ranging signals would be defined.

## L5/E5b Precise Point Positioning Service

Precise Point Positioning (PPP) is a technique to provide higher accuracy position fixes than available from standard GNSS measurements, by applying corrections to the satellite orbit and clock models used by the GNSS receiver.

### A: Standard PPP Service

The Australia/New Zealand Southern Positioning Augmentation Network (SouthPAN) SBAS intends to provide PPP corrections to GPS and Galileo observations, initially in the L5 signal (utilising the MT32 fields for GNSS Satellite clock-ephemeris error corrections and covariance matrix), eventually migrating to a dedicated signal using the E5b (1207.14 MHz) GNSS signal band. Details are provided in the SouthPAN Service Definition Document for Open Services[[3]](#footnote-4).

The “PPP via SouthPAN” (PVS) service has the following indicative performance specification:

|  |  |
| --- | --- |
| Performance Measure | Target |
| Horizontal Position Error 95% | < 0.375 m |
| Vertical Position Error 95% | < 0.525 m |
| Convergence Time | <80 mins |
| Service Availability | >0.995 |

*As an option*, UK SBAS may support the transmission from GEO of PPP corrections, compatible with the SouthPAN PVS Service, either within the MT32 field of the L5 signal, or as a dedicated E5b signal.

### B: PPP with Integrity Service

It is recognised that the Galileo GNSS broadcasts open service GPS and Galileo PPP corrections on the E6 frequency as the Galileo High Accuracy Service (HAS), with observed performance at least as good as that specified for SouthPAN PVS. Furthermore, other institutional and commercial PPP service providers potential promise even better performance, therefore the value of a comparable future UK SBAS PPP signal in space is questionable.

However, such a service may have substantial value to many transport applications if the PPP corrections are protected with an integrity flag, i.e. if the user equipment were to raise an alert if any of the “Max Error” components of the PPP message were to exceed specified limits.

Respondent with expertise in this domain are invited to propose high-level technical solutions to provide PPP and/or PPP + Integrity services, and to propose viable performance limits for these services.

## Space-Based Time Transfer Open Service

As stated previously it is intended that the UK SBAS services “*will work alongside the National Timing Centre as part of the wider UK PNT framework”[[4]](#footnote-5)*. As such a considered capability is for a Space Based Time Transfer Open Service that accounts for the following:

* UK SBAS shall transmit Open Service (OS) Signals in Space (SiS) at a frequency to be defined (i.e. not necessarily in the GNSS frequency bands, nor necessarily from Geo), which may be processed by receiving equipment at fixed, known locations to provide synchronisation to UTC(NPL) with an accuracy better than 1 microsecond (requirement), ideally better than 100 nanoseconds (objective).
* The UK SBAS Time Transfer Open Service shall be fully independent of GNSS.
* The UK SBAS Time Transfer Open Service shall have availability > 98%.
* The UK SBAS Time Transfer Open Service coverage area is TBD:
  1. As a minimum to cover the UK Exclusive Economic Zone surrounding the United Kingdom, as for the SBAS OS/SoL services.
  2. As an objective, to cover the Western and Southern Atlantic beyond British Overseas Territories in these regions.
  3. Ideally, to be potentially extensible to become a global or near-global service, with cooperation of international partners.
* The UK SBAS Time Transfer Open Service system architecture shall demonstrate resilience against malicious and unintentional signal interference, as appropriate for a service to be used by UK Critical National Infrastructure. The detailed resilience requirements are classified and may be disclosed at a later point in any UK SBAS procurement process.
* The UK SBAS Time Transfer Open Service may or may not be delivered from Geostationary platforms.

Respondent with expertise in this domain are invited to propose high-level technical solutions to provide resilient open time transfer services from space, and to propose viable performance limits for these services.

## Space-Based Time Transfer Encrypted/User Access Controlled Service

As stated previously it is intended that “*The Ministry of Defence (MOD) will develop a new ‘MOD time’ to provide a system of last resort to enhance national resilience”[[5]](#footnote-6)*, and that UK SBAS may be one of a number of channels to distribute ‘MOD Time’.

Mission requirements for the UK SBAS Time Transfer Controlled Access Service may be assumed to be comparable to those presented for the Time Transfer Open Service. In addition:

* The UK SBAS Time Transfer Controlled Access Service will implement mechanisms for signal encryption and user access control. Full requirements are TBD but may be assumed to be as appropriate to support UK MoD services.
* The UK SBAS Time Transfer Controlled Access Service shall be useable by slow-moving (e.g. maritime) vehicles, with 2D position uncertainty of 30 m (95%) [TBC].

Respondent with expertise in this domain are invited to propose high-level technical solutions to provide resilient secure time transfer services from space, and to propose viable performance limits for these services.

## Internet Data Access Services

It is envisioned that UK SBAS will provide Data Access Services (DAS) via the internet through high-availability cloud-based infrastructure. The EGNOS Data Access Service (EDAS) and SouthPAN Data Access Service (SouthPANDAS) propriate suitable models for a UK SBAS DAS.

The SISNeT protocol as used by EDAS and SouthPANDAS shall be used by UK SBAS DAS. The set of sub-services to be included within the DAS will depend upon the eventual implementation of UK SBAS but as discussed within this document, may include any subset of the following:

* UK SBAS L1 data messages
* UK SBAS DFMC data messages
* GNSS Reference Equipment Observables
* UK SBAS PPP correction data and metadata
* UK SBAS PPP correction data and metadata and PPP integrity flags
* UK SBAS Geo Ranging meta data
* UK SBAS Time Transfer Open Service meta data
* UK SBAS Time Transfer Encrypted Service meta data
* UK SBAS Time Transfer Encrypted Service user access key management.

Respondents are invited to add additional message categories designed to support non-aviation use cases such as maritime, rail, road and future aviation users (eg. UAVs and eVTOLs).

Respondent are invited to propose high-level technical and administrative solutions to provide these capabilities.

## UK SBAS Maritime Service

The recently published EGNOS Safety of Life assisted service for Maritime users (ESMAS) Service Definition Document defines an approach which may become an accepted standard for maritime safety services using SBAS. This concept utilises threshold values in the User differential Range error Indicator (UDREI) and Grid Ionospheric Vertical Error Indicator (GIVEi) in the SBAS L1 SiS as proxy fields for satellite alert status.

* The UK SBAS L1 SoL Service *may* be extended to provide ESMAS-type alerts as a UK SBAS Maritime Service.
* A UK SBAS Maritime Service *may also* be implemented using the maritime VHF Data Exchange System (VDES) as a channel for delivery of GNSS maritime safety alerts.

In either case, UK SBAS User Support Services will be required to generate and disseminate corresponding Maritime Safety Information notifications.

Respondent are invited to propose high-level technical and administrative solutions to provide these capabilities.

## Other Transport Services

As well as services for the aviation and maritime domains as described above, it is envisaged that SBAS in general and UK SBAS in particular may be used to support other transport domains such as rail, autonomous vehicles and uncrewed aerial vehicles. There are, as yet, no standards for use of SBAS in these domains. The “PPP with Integrity” service discussed previously may or may not address the needs of these sectors.

Nevertheless, respondents with relevant expertise are invited to propose high-level technical solutions for integrity service delivery mechanisms suitable for some or all of these domains, at the respondent’s discretion.

## User Support Services

As well as providing the technical means by which the signals are generated on ground and transmitted from geostationary spacecraft, the UK SBAS mission architecture will also include:

* A UK SBAS user help desk.
* Means to support certification of UK SBAS services to be used for safety of life applications.
* Means for the generation and dissemination of UK SBAS service availability information, specifically in the form of SBAS Notifications to Air Missions (NOTAMS).
* Means for the generation and dissemination of UK SBAS Maritime Safety Information (MSI) notices.
* Means for the development and implementation of working agreements between the UK SBAS system operator and the air navigation service providers/airfields implementing UK SBAS procedures.

Respondent are invited to propose high-level technical and administrative solutions to provide these capabilities.

1. *UK Government 10 Point PNT Framework,* DSIT <https://www.gov.uk/government/news/critical-services-to-be-better-protected-from-satellite-data-disruptions-through-new-position-navigation-and-timing-framework> [↑](#footnote-ref-2)
2. *Space Industrial Plan,* DSIT <https://www.gov.uk/government/publications/space-industrial-plan#:~:text=The%20Space%20Industrial%20Plan%20aims,in%20a%20contested%20space%20environment> [↑](#footnote-ref-3)
3. Service Definition Document for Signal-in-Space Open Services: Southern Positioning Augmentation Network. https://www.ga.gov.au/\_\_data/assets/pdf\_file/0011/123320/SBAS-STN-0001\_03\_SouthPAN-SDD-for-SIS-OS.pdf [↑](#footnote-ref-4)
4. *Space Industrial Plan,* DSIT <https://www.gov.uk/government/publications/space-industrial-plan/space-industrial-plan-from-ambition-to-action-advancing-uk-space-industry#:~:text=Position%2C%20Navigation%20and%20Timing%20(%20PNT,the%20wider%20UK%20PNT%20framewor> [↑](#footnote-ref-5)
5. *Space Industrial Plan,* DSIT <https://www.gov.uk/government/publications/space-industrial-plan/space-industrial-plan-from-ambition-to-action-advancing-uk-space-industry#:~:text=Position%2C%20Navigation%20and%20Timing%20(%20PNT,the%20wider%20UK%20PNT%20framewor> [↑](#footnote-ref-6)