

# GNSS SERVICES SUPPORTING CIVIL AVIATION IN THE UK



April 2024  
An RAeS ATM Specialist Group  
Briefing Note No 3



# GNSS SERVICES SUPPORTING CIVIL AVIATION IN THE UK

## BACKGROUND

- Over the last 25 years, civil aviation has become more dependent on the use of Global Navigation Satellite Systems (GNSS) for Positioning, Navigation and Timing (PNT) applications.
- GNSS is already the foundation of Performance-based Navigation (PBN), Automatic Dependent Surveillance – Broadcast (ADS-B) and Automatic Dependent Surveillance – Contract (ADS-C). GNSS also provides a common time reference used to synchronise systems, avionics, communication networks and operations, and supports a wide range of non-aviation applications
- In the UK we are solely reliant on user access to the US owned Global Positioning System (GPS), developed, maintained and operated by the US Space Force.
- Prior to its EU exit on 31 December 2020, the UK was part of the EU space programme, including development of the Galileo core constellation and had access to the European Geostationary Navigation Overlay System (EGNOS) providing a Space-Based Augmentation System (SBAS). EGNOS included a Safety-of-Life (SoL) service supporting Localiser Performance with Vertical guidance (LPV) approaches to instrument runways. This offered operators of aircraft with suitable airborne equipment a 3-Dimensional stabilised approach capability to Category I operating minima down to a Decision Height of 200 feet and RVR/Visibility down to 550 m, depending on the approach and runway lighting system<sup>(1)</sup>.
- On 21 June 2021, the EU withdrew the EGNOS Working Agreements to 18 aerodromes, thereby removing LPV lines of minima affecting 39 instrument approach runway ends.
- Since then, the UK has been the only European state without an SBAS service and, therefore denied the capability for aerodromes to offer stabilised instrument approaches to LPV minima.
- Aerodromes used by regional and general aviation operators have been most impacted by this action, including some Public Service Obligation (PSO) contracts. Given that it was UK policy at the time to implement changes adding LPV minima to all UK instrument runways, many more aerodromes have been affected.

## GNSS SPECIFICATIONS FOR CIVIL AVIATION

- The specifications pertaining to the use of GNSS in civil aviation are derived from International Civil Aviation Organization (ICAO) Standards and Recommended Practices (SARPS) detailed in Annex 10 and the Doc 9849. This includes both the core-constellations, such as GPS, Galileo and BeiDou and the various augmentation systems, such as ABAS, SBAS and GBAS.
- Whereas there are multiple satellite applications based on different satellite/ground configurations, ICAO compliance provides civil aviation with global interoperability and compatibility between both airborne, space segment and ground equipment and, therefore, across global operations and procedures.
- GNSS SBAS augmentation systems, such as the European EGNOS and the US Wide Area Augmentation System (WAAS), are regional in nature. The resources required to develop and operate a State SBAS, including expertise and cost is considered prohibitive.

## DEVELOPMENTS SINCE EU EXIT

- Post the EU exit, the Cabinet Office, in conjunction with BEIS (the former Department for Business, Energy & Industrial Strategy) and the UK Space Agency (UKSA) were studying future UK requirements for satellite systems under the Space Based Position, Navigation and Timing (PNT) Programme (SBPP).
- In February 2021, an unsolicited outline proposal was received by the Cabinet Office from a consortium led by Inmarsat for a UK SBAS Demonstrator.

<sup>(1)</sup>AMC5 CAT.OP.MPA.110 Aerodrome operating minima (caa.co.uk)

- The Inmarsat proposal was perhaps opportunistic as it was essentially a repurposing of the SBAS transponder on Inmarsat's I-3 F5 satellite in geostationary orbit at 54° west. I think most industry observers would have been surprised had it not worked, but it must be noted that a demonstrator is not a fully worked-up and operational and certified Safety-of-Life (SoL) service for civil aviation.
- In September 2021 the UK Space Strategy was published, but with no specific mention of space technologies, such as SBAS. PNT was mentioned under key civil and military defence priorities, but only in so far as saying that "the government is evaluating the case for investing in resilient PNT capabilities through a mix of innovative new terrestrial and space-based technologies". Many in the industry saw this as a reference to the UK government investment in Low-Earth-Orbit (LEO) satellite business, OneWeb. It does nothing for SBAS, being neither an ICAO recognised system or suitable for civil aviation purposes.
- On 26 May 2022, the government announced a Strategic Framework for Aviation<sup>(2)</sup> with the publication of 'Flightpath to the future', which sets out plans to create a modern, innovative and efficient aviation sector. Within the section titled 'Embracing innovation for a sustainable future', the report highlights "using space to modernise our transport network". This then links to the National Space Strategy – mentioned above.
- Published in October 2022, the House of Commons Select Committee took evidence on the UK Space Strategy and UK Satellite Infrastructure<sup>(3)</sup>. From the summary of the report, the Select Committee states:
  - We urge the government to publish a National PNT Strategy and set out what ground and space-based components will be used in a UK PNT system.
- At the General Aviation Partnership<sup>(4)</sup> meeting held on 23 February 2023, the CAA reported that: The UK government has said that readmission of the UK into Galileo and EGNOS is unlikely and that means that we would need to run our own SBAS service. The CAA went on to report that work is ongoing to explore the possibility of enabling such a service. Exploration work is being undertaken within the established Space-Based Positioning Navigation and Timing Programme (SBPP) with a project to explore the capacity for an additional SBAS signal, as well as options for a UK SBAS. This includes the business case for such a capability.
- In central government, there is recognition of the need to deliver crucial navigation services for aviation and maritime and in other areas to regenerate UK strategic capabilities in the PNT domain.
- Both DfT and BEIS (now the Department for Science, Innovation and Technology) have stood up PNT offices to focus on the UK PNT capability, including accessing a Safety of Life (SoL) SBAS capability.
- The CAA notes that it is important that the two capabilities of UK-SBAS and UK-GNSS (primary PNT) are separated. Both are being explored but they are not the same undertaking.

## CURRENT STATUS

- Updated in April 2023, the National Protective Security Agency (NPSA) highlighted 13 Critical National Infrastructure (CNI) sectors. This includes Transport and Space<sup>(5)</sup>.
- GNSS-based services are vulnerable to both unintentional and intentional (malicious) interference and natural phenomena, such as strong solar winds/flares associated with Space Weather. Mitigation is typically provided through autonomous navigation systems, such as inertial reference systems (IRS) and retained, spectrum inefficient ground-based radio frequency technologies, such as VOR, NDB and DME.
- Malicious interference, such as jamming and now spoofing is relatively easy and becoming more widespread.
- On 18 October 2023, the Department for Science, Innovation and Technology announced that critical services would be better protected from satellite data disruptions through a new Position, Navigation and Timing framework<sup>(6)</sup>
- Within the 10 points outlined, they included:
  - eLORAN: develop a proposal for a resilient, terrestrial and sovereign Enhanced Long-Range Navigation system to provide back-up Position and Navigation.
  - 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.

<sup>(2)</sup>A strategic framework for aviation – GOV.UK ([www.gov.uk](http://www.gov.uk))

<sup>(3)</sup>UK space strategy and UK satellite infrastructure – Committees – UK Parliament

<sup>(4)</sup>General Aviation Partnership (GAP) | Civil Aviation Authority ([caa.co.uk](http://caa.co.uk))

<sup>(5)</sup>Critical National Infrastructure | NPSA

<sup>(6)</sup>Critical services to be better protected from satellite data disruptions through new Position, Navigation and Timing framework – GOV.UK ([www.gov.uk](http://www.gov.uk))

- On the same day – 18 October 2023, the UK Space Agency and Department for Science, Innovation and Technology published two pieces of research and analysis related to Space-Based PNT Technical Concepts and the economic impact on the UK of a disruption to GNSS .
- The Space-Based PNT Technical Concepts report summarises the 10 technical concepts for delivering Positioning, Navigation and Timing services developed under the Space Based PNT Programme (SBPP).
- Concept ID no. 8 is the UK SBAS proposal described as Geostationary Orbit (GSO) Space-Based Augmentation to Existing GNSS, providing additional information to improve resilience and accuracy of existing GNSS.
- Criterion and Comments are provided for each concept, including performance, advantage to the UK, resilience, schedule, user & value, risk to deliverability and system security.
- The economic impact on the UK of a disruption to GNSS report was prepared by London Economics, one of Europe's leading specialist economics and policy consultancies. The report effectively monetises the economic benefit to the UK from the use of GNSS at £13,622m per annum. The share for aviation is estimated at 1.4% or approximately £191m per annum. The impact on maritime is 4.2%.
- The 7-day GNSS outage scenario used in the report is associated with negligible levels of economic loss in aviation, primarily due to a number of back-up technologies. The report does, however, acknowledge that productivity losses will be felt across the sector.

## CONCLUSIONS

- The frustration for the UK civil aviation industry is that pre-EU Exit, we had a strategic roadmap for GNSS based on ICAO developments and supported through our membership of both the EU Galileo and EGNOS space programmes. This included the successful rollout of stabilised 3-Dimensional instrument approaches down to CAT I minima at 18 aerodromes in the UK.
- The EU Exit has removed this capability and three years later left us talking about UK Technical Concepts. It feels as though we have gone back in time by over 15 years.
- At present, the UK government is still talking about technical concepts and assessing them against criterion, against which UK civil aviation (on its own) will likely find it difficult to make a business case.
- Conscious of the increasing vulnerability of GNSS and its importance and role within future civil aviation concepts, ICAO is amending SARPS to provide greater resilience through development of Dual-Frequency, Multi-Constellation (DFMC) architectures. The obvious application for UK domestic coverage is use of GPS and Galileo with frequencies L1/E1 or L5/E5a providing ABAS, SBAS and GBAS services, including ABAS evolutions as ARAIM integrity support messages. From a UK perspective, it is difficult to see how such concepts will be delivered by a stand-alone UK space industry.
- The 18 October 2023 Space-based Technical Concepts already alludes to challenges for a UK SBAS:
  - Full Operational Capability is expected 5 years after kick-off, due to the relative simplicity of the platform and payload. Potential for an initial regional service using only redundant, potentially hosted payloads.
  - But on the risk to deliverability, the report notes that it will be challenging to find 6 GEO spacecraft to act as hosts from which to deliver the service which may result in the need for dedicated GEO spacecraft greatly increasing costs.
- Given the cost pressures on government and the recent history of national infrastructure projects eg, HS2, plus the challenges highlighted in the Space-based Technical Concepts report, it is difficult to see a UK SBAS being financially supported by government.
- It is questionable how the objectives and goals of 'Flightpath to the Future' will be fully realised, especially for new entrants, without enhancements to the UK's current GNSS infrastructure, ie GPS.
- Aside from questions of funding, there are also uncertainties related to:
  - What SBAS performance level?
  - Service area – coverage?
  - Security aspects?
  - Who will be the certified Air Navigation Service Provider (ANSP) operating the service?

<sup>(7)</sup>Space-based PNT Technical Concepts – GOV.UK ([www.gov.uk](http://www.gov.uk))

<sup>(8)</sup>Report: The economic impact on the UK of a disruption to GNSS – GOV.UK ([www.gov.uk](http://www.gov.uk))



- Acceptance by ICAO?
- Future evolutions and keeping pace with EGNOS V3.0 and DFMC?
- Noting that Space-Based Augment Systems (SBAS) are typically regional in nature and/or financed by wealthy regional nations, the probability of UK funding, resourcing, developing and delivering a UK SBAS must be considered remote.

## SUMMARY

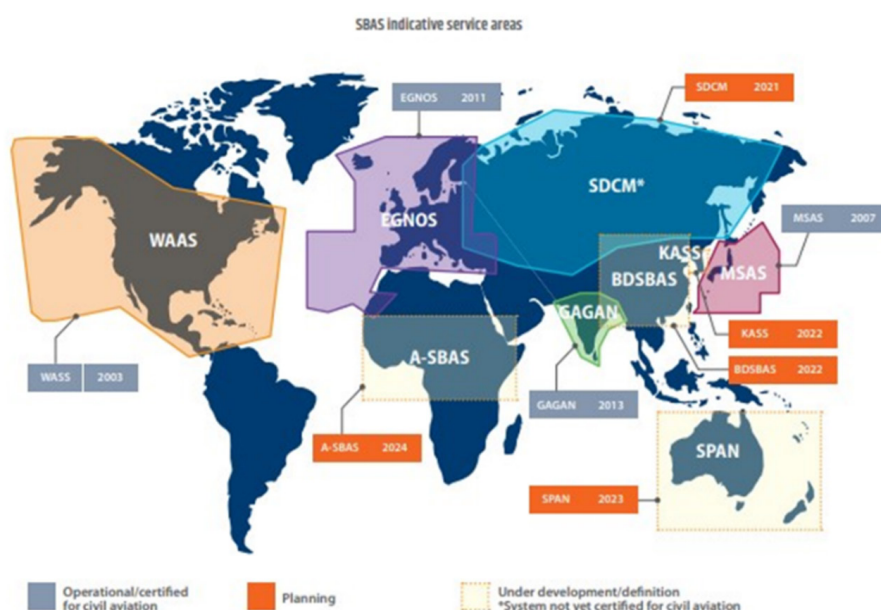
- The UK civil aviation industry would like to be optimistic that there are prospects for a UK SBAS capability and we will see LPV lines of operating minima reappearing on our instrument approach charts. If the financial justification can be made, and a lot depends on the business case from other sectors and other aviation applications not yet realised, then it could easily be 7 to 10 years away. Implementation of GNSS services has typically been regional, primarily due to cost and the scale of project. Readmission to EGNOS would be much quicker and cheaper, but then it always was.

RAeS Air Traffic Management Specialist Group – April 2024

## REFERENCES

- ICAO Annex 10 – Aeronautical Telecommunications Volume I, Radio Navigation Aids. Available at: <https://store.icao.int/>
- ICAO Doc 9849 – Global Navigation Satellite System (GNSS) Manual. Available at: <https://store.icao.int/>
- ABAS – Aircraft-Based Augmentation System. ABAS is an avionics implementation that processes GNSS core constellations signals to deliver the accuracy and integrity required to support en route, terminal and non precision approach operations.
- SBAS – Satellite-Based Augmentation System. SBAS uses a network of ground reference stations and provides signals from geostationary orbit (GEO) satellites to support operations from en route through to approaches with vertical guidance over a large geographic area.
- GBAS – Ground-Based Augmentation System. GBAS uses monitoring stations at airports to process signals from core constellations and broadcast corrections and approach path data to support precision approach and terminal position service operations.
- ARAIM – The availability of multiple constellations and frequency diversity offers the possibility to develop advanced RAIM (ARAIM) that could support high availability for en route through to non precision approach and also support approach procedure with vertical guidance.

Cover Images: UK MoD and Inmarsat



## CONTACT

The Royal Aeronautical Society (RAeS) welcomes and encourages further engagement on this topic. Please direct all correspondence to the RAeS Committee via the contact details below:

Jordan Penning, Policy and Public Affairs Executive: [Jordan.Penning@aerosociety.com](mailto:Jordan.Penning@aerosociety.com)

## ABOUT THE ROYAL AERONAUTICAL SOCIETY

The Royal Aeronautical Society is the only global organisation serving the entire aerospace, aviation, and space community as both a learned society and a professional engineering institution. As such, the Society is independent, evidence-based and authoritative, relying on a body of knowledge going back more than 150 years. The Society plays a leading role in influencing opinion on aerospace aviation and space matters, through various means, including its publications, social media profile, interaction with government and an extensive events programme.

**Twitter:** @AeroSociety

**Instagram:** @royalaerosociety

**LinkedIn:** Royal Aeronautical Society

**Facebook:** Royal Aeronautical Society

**YouTube:** @Aerosociety

