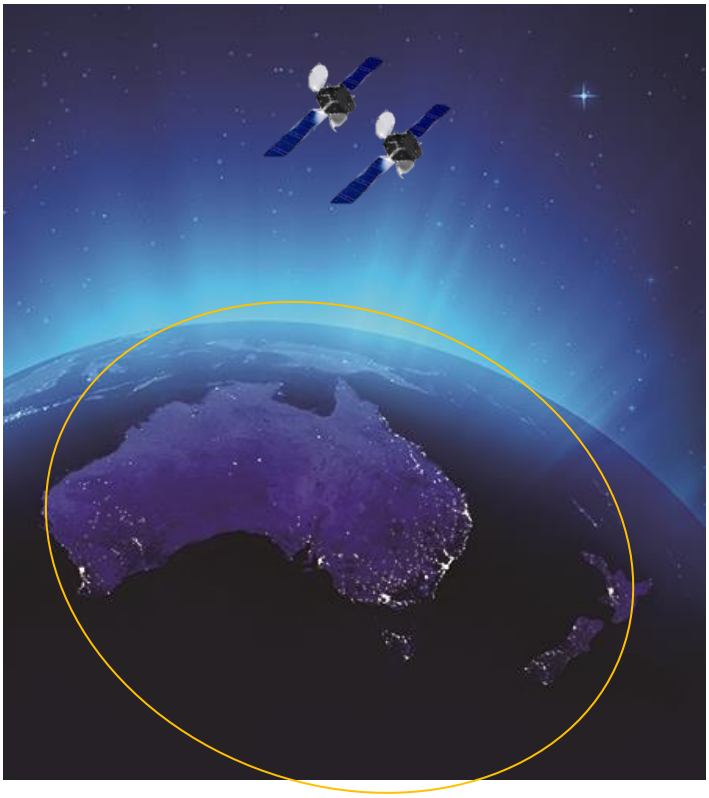
SATELLITE BASED AUGMENTATION SYSTEM (SBAS) FOR AUSTRALIA

AN AIN POSITION PAPER SUBMITTED TO VARIOUS GOVERNMENT DEPARTMENTS BY MR KYM OSLEY AM, CSC, EXEC SECRETARY AIN



What are GNSS Augmentation Systems?

Augmentation of global navigation satellite systems (such as GPS) is a method of significantly improving the accuracy, reliability, integrity, and availability of the system through the integration of additional external information into the calculation process.

There are many such commercially available systems. Some augmentation systems transmit additional information about sources of error (such as clock drift, ephemeris, or ionospheric delay), while others provide direct measurements of how much the signal was off in the past. The Ionosphere contributes the largest error.

There are two key ways that the augmentation signals can be provided to a GNSS receiver – from a ground transmitter (known as a Ground Based Augmentation System (GBAS)), or from a satellite transmitter (known as a Space Based Augmentation System (SBAS)).

GBAS is less costly than SBAS, but is much shorter range. GBAS networks generally support receivers within 23 nautical miles with their line-of-sight signals transmitted in the VHF bands. GBAS is targeted at precision approach (CAT-I to CAT-III) while SBAS is targeted at non-precision approach (down to CAT-I).

Airservices has installed a GBAS capability at Sydney Airport to support precision approaches. Due to its relatively high establishment and maintenance costs it is unlikely to present a practical solution for lower traffic/passenger volume regional aerodromes.

SBAS supports wide-area or regional augmentation through the use of additional satellite-broadcast messages. Such systems are commonly composed of multiple ground stations, located at accurately-surveyed points. The ground stations take measurements of the GNSS satellites that are in view and other environmental factors which may impact the signal received by the users. Using these measurements, information messages are created and sent to one or more (geo-stationary communications) satellites for broadcast to the GNSS receivers of the end users. The additional expense comes from needing more ground uplink stations and having to pay for capacity on (generally) extant geo-stationary communications satellites over the area to be serviced.

There is currently no aviation compliant SBAS in Australia.

What is SBAS?

SBAS is a ground network providing augmented GPS signals with integrity over a wide area by using space-based signal relay.

SBAS can:

- improve GPS availability to 99.999%,
- provide an Integrity message consistent with Safety of Life (SOL) operations[1],
- improve accuracy (to sub-metre), and
- meet international standard: RTCA and/or ICAO Annex 10 DO-229D to provide interoperability.

In 1994, the US DOT and the FAA jointly initiated the development of the Wide Area Augmentation System (WAAS). This was developed because legacy ILS systems were expensive to deploy and maintain, and the airborne procedures were difficult to execute. WAAS is intended to provide lateral and vertical navigation for non-precision approaches for all users at all locations with a minimum equivalence to CAT-I. The same year the European Council approved the development of the European Geostationary Navigation Overlay Service (EGNOS). Both WAAS and EGNOS as other SBAS's conform to the International Civil Aviation Standard (ICAO DO-229D)

SBAS procedures are now in effect in the US, Canada, Mexico and Europe. Regional Aviation, Business Jets and General Aviation both fixed wing and rotorcraft are using SBAS procedures for LPV (lateral and vertical guidance to Cat 1 minima, 200ft) at an increasing number of aerodromes. WAAS is providing precision approaches at over 4000 runway ends. The US and Europe are realizing safer and

[1] For aviation and other safety of life services, INTEGRITY is a key performance factor. INTEGRITY is a confidence message that alerts the operator that the system reporting can be trusted. ICAO SBAS reports any detected lack of integrity within 6 seconds.

more efficient operations and cost savings through the use of SBAS and the dismantling of legacy ILS infrastructure. The major carriers have previously been opposed to paying increased costs to cover SBAS or for aircraft equipped with SBAS, but that appears to be changing. The new Airbus A350 is SBAS equipped and performing LPV procedures. The new B737-Max is also SBAS equipped.

The support for SBAS in Australia and New Zealand aviation comes from GA, business and regional carriers. The major carriers are generally against increased costs.

What is the potential benefit of a public wide-area precise spatial navigation system to Australia?

The SBAS (ICAO SBAS) signal is like a GPS signal and is free-to-ground. Because the SBAS signal is free, available everywhere and is fixed to an international standard, the mass market adoption has been prolific. SBAS processing is available in virtually all GPS chip sets. Therefore most receivers are SBAS enabled.

SBAS is generating efficiencies in the US and Europe in agriculture, transport, roads, rail and maritime, utilities, public works, forestry, mapping and surveying and much more. The reason is: public signal, low cost receivers-the power of the mass market, wide area availability and ease of use. SBAS in the US dominates all positioning, navigation and timing (PNT) sources as the preferred augmentation solution.

Precise positioning has emerged as a critical capability for many sectors of the Australian economy including maritime, land transport, asset management, defence, border protection, agriculture, mining, engineering and construction. SBAS would raise the base level of positioning, navigation and timing for all these industries and individual Australians. This would especially benefit regional and rural Australia where alternate augmented GNSS services are limited and expensive.

It is estimated that a nationwide, high quality positioning infrastructure in Australia could generate at least $32 billion in additional productivity gains over the next 20 years.[2]

What were the key outcomes of the most recent Review of SBAS in 2009/2011?

An initial SBAS review by Booze in 2009, led in 2011 to infrastructure portfolio agencies[3], in consultation with other portfolios, finalizing a review of the efficacy of an Australian SBAS capability, as well as other available options, for completing Approach with Vertical Guidance (APV) coverage in Australia.

The main finding of the review was that as of 2011, it was difficult to justify funding a SBAS system in Australia in terms of just considering aviation operations at smaller aerodromes (which was the key focus of the 2011 study).

[2] The Allen Consulting Group (2008) The Economic Benefits of High Resolution Positioning Services. Prepared for the Victorian Department of Sustainability and Environment and the Cooperative Research Centre for Spatial Information. November 2008.

[3] In its December 2009 Aviation Policy White Paper, *Flight Path to the Future*, the Government asked Infrastructure portfolio agencies, in consultation with other portfolios, to review SBAS in more detail.

The 2011 report noted that a future Review might do a more detailed cost benefit analysis, undertaking a comprehensive SBAS industry demand survey; examining different funding options including private investment; the impact of increased satellite coverage and new technologies in the coming years from other countries and the implications of entering into an agreement or partnership with other countries in the region for satellite access.

To quote the 2011 Report: '…*It is important to note that a greater body of work would need to be undertaken to deliver high accuracy costings and economic benefits against each of these options – for inclusion in any submission to the Government to support a final informed decision on whether to consider progressing an SBAS capability, including whether there were quantifiable benefits and interest from other industry sectors*…'.

What other countries now have SBAS?

The following countries have SBAS (ICAO SBAS) in various stages of implementation:

Operational as at 2016:

- US –Wide Area Augmentation System (WAAS) – there are now more GPS/WAAS supported approaches than CAT 1 ILS
- Canada – a part of WAAS
- Mexico – a part of WAAS
- Europe (Joint collaboration) -EGNOS
- Japan – Multi-Function Satellite Augmentation System (MSAS)
- India – GPS & Geo-Augmented Navigation System (GAGAN)

Being developed as at 2016:

- Russia – System for Differential Corrections and Monitoring (SDCM)
- China – Satellite Navigation Augmentation System (SNAS)

Being considered as at 2016:

- Korea plans to tender for an SBAS in 2016.
- South America and Caribbean – SACCSA is reported as implementing an initial SBAS capability over the Caribbean and parts of South America.
- African nations are considering a collaborative approach to an SBAS system based on the European EGNOS system. A preliminary phase is being supported by funding from the intra-ACP 10th European Development Funds.

What has changed since the 2011 Review?

The following developments have occurred since the 2011 Report:

- ICAO resolution 37/11: APV is to be implemented across all instrumented runways by 2016. It is likely that SBAS is the only cost effective solution for Australia's 273 aerodromes.
- SBAS is recognized as best positioning source for 'ADS-B out'.
- There is an increasing demand (or expectation) for greater availability and higher accuracy for positioning, navigation and timing across the aviation/transport sectors, security sector, many industries and for personal applications. The contribution made by the presence of accurate and reliable GNSS is expected to rise to $7.8B-$13B by 2020.[4]
- Many SBAS networks have now been implemented in other countries, providing a better idea of actual costs and benefits. SBAS is providing greater productivity through efficiencies and cost savings in these countries.
- SBAS discussions are moving forward in New Zealand, with the emerging preference for a joint project with Australia. A report commissioned by the NZ CAA indicates a favourable cost/benefit ratio for even just NZ aviation alone, without other benefits being considered.
- The NZ Department of Transport are strongly in support of SBAS and have indicated they would like to participate in any study with Australia.
- PNG have also indicated strong interest
- The Government's national space policy has now been developed and published. Australia's Satellite Utilisation Policy was issued in 2013, which is supportive of taking a longer term view for the development of high accuracy navigation infrastructure to support transport and a wide range of industries.
- The Australian Government has developed a National Positioning Infrastructure Plan which supports investment in domestic ground infrastructure to deliver accurate and reliable positioning information to scientific users across Australia.

Geo-Science Australia – do they have an interest in GNSS augmentation systems?

Consideration could be given to inviting Geosciences Australia to also be a co-sponsor. Geoscience Australia receives Government funding and is responsible for providing very accurate geo-referencing across Australia and the region. Geo-Science Australia activities in this area include cooperatively operating and maintaining a network of approximately 100 reference stations across Australia and the South Pacific. These stations are essentially very accurately surveyed ground sites with a continuously operating transmitter at them against which users can get a very accurate ground reference. SBAS (ICAO SBAS) would raise the base level of national positioning, navigation and timing (PNT) such that all Australians could access higher precision with greater availability and integrity using the everyday commercial devices available from the global mass market.

Summary

SBAS was developed as an aviation system. Because it was implemented as an international standard and the signal is free to ground broadcast over a wide area with consistent performance, SBAS has been embraced by the mass market and

[4] Acil Allen[1] estimated that in 2012 $2.3-3.7 billion was added to Australia's GDP by GNSS, and that will rise to $7.8-13 billion by 2020.

now has become the preferred source of GNSS augmentation for WAAS, EGNOS, MSAS and GAGAN users. Many of the GNSS receivers used throughout Australia's sectors are SBAS enabled, but the augmentation signal is not available. The SBAS global footprint is increasing safety and commercial advantages for its citizens.

SBAS could provide Australia with:

- national productivity enabling infrastructure,
- the only cost effective solution for aviation to improve access and safety throughout its airspace, and
- regional leadership with possible expansion to near neighbors

SBAS could potentially be progressed as a joint project between Australia and New Zealand providing cost sharing and expanded area of performance.

Recommendation

It is recommended that a Government funded update of the 2009/2011 SBAS Reviews be conducted in late 2016, with a focus on non-aviation users and regional cooperation and alternate management and funding options.

Kym Osley AM, CSC
Executive Secretary
Australian Institute of Navigation
Canberra
March 2016