Guidance Document for Implementation of GBAS in the Asia /Pacific Region

1. OBJECTIVES AND SCOPE OF THE GUIDANCE DOCUMENT

The objectives and scope of this document is to provide guidance on the determination of the requirement for a Ground Based Augmentation System (GBAS) to support precision approaches at a specific airport

2. EXECUTIVE SUMMARY

Approach and landing at airports is a critical stage of flight. In adverse weather conditions, navigation guidance to support an approach provides for an additional level of safety for the activity. GBAS and ILS provide precision approach capability, and with the ICAO plan to transition to GNSS, GBAS will eventually be the preferred navigation aid to support precision approaches.

3. ROLES AND RESPONSBILITIES OF STAKEHOLDERS

Stakeholders are responsible to provide a safe service with optimal community benefit. Relevant information about toles of ANS providers and regulators can be reference to Appendix B of ICAO Doc 9849 GNSS Manual.

4. PERFORMANCE INDICATORS

Performance indicators are quantifiable indicators got by measurements/statistics to show the performance or progress towards the intended result(s). Each state should consider to establish a set of performance indicators against which the performance of GBAS is evaluated. Examples of performance indicators established by states in the region include:

- Operational Availability of the GBAS
- Reliability (Mean Time Between Outage) of the GBAS
- Mean Time To Repair
- Number of GBAS approaches performed into the aerodrome
- Operation and Maintenance costs

Since performance indicators are associated with the evaluation on the performance or progress towards the intended result(s), each State may focus on different aspects with benefits from GBAS to serve their own purpose and set up their own set of performance indicators against the performance of GBAS for evaluation under post-implementation review.

5. IMPLEMENTATION PROCESS FOR GBAS

a. Overview

This document is intended to provide **guidance only** when implementing and certifying a GBAS installation and service within their region. The material contained within this document is based on the experience of other States within the APAC region, ICAO documentation, and other publicly available material.

The GBAS is a Global Navigation Satellite System (GNSS) based precision approach system consisting of the ground based hardware and software that augments core satellite constellation signals. The system uses the concept of differential corrections to augment the satellite constellation signal in order to provide the required integrity, continuity, accuracy, and availability to support precision approaches.

The GBAS consists of three segments:

- **Space Segment**. The space segment consists of the GPS and/or other satellite constellations which provides the ranging signals and orbital parameters. Both GBAS ground facility and airborne systems use the ranging signals to determine positioning.
- **Ground Segment**. The ground segment consisting of GBAS ground facility/station, such as reference receivers with their antennas installed at precisely surveyed points, provides:
  - differential corrections to remove the range measurement errors that are common to the ground and aircraft sub-systems (Message Type 1);
  - GBAS ground facility specific data, including the integrity parameters to monitor and bound GBAS service integrity risk (Message Type 2); and
  - path points which define the Final Approach Segment (Message Type 4).
- **Airborne Segment.** The GBAS receiver on the aircraft applies the corrections to satellite ranging signals broadcast by the GBAS to obtain a position estimate with the required accuracy. The differentially corrected position is used, along with path-point data, to supply deviation signals to aircraft systems supporting precision approach and landing operations. In addition, the aircraft uses integrity parameters broadcast by the GBAS ground facility to perform integrity checks with protection levels on the aircraft's corrected position estimate.

b. Frame, Phases and Elements of GBAS Implementation Process

Relevant information can be reference to Chapter 7 of ICAO Doc 9849 GNSS Manual.

i. Operational Need Analysis / Concept of Operations

When considering whether to implement a GBAS, it is important to consider how the GBAS will be used within the existing Air Traffic Management (ATM) environment and the benefits that it will deliver to the State. This should be one of the first steps when deciding whether to install a GBAS. The analysis should involve a thorough examination of:

- current approach capability into the airport including objectives, measures of effectiveness, operational policies and constraints, current capability description, modes of operation, and the existing support environment;
- the reasons for changing or supplementing the existing approach capability into the airport with a GBAS;
- concepts for the proposed GBAS capability including objectives, measurements of effectiveness, operational policies and constraints, proposed capability description, proposed modes of operation, integration issues within the existing ATM environment, stakeholders and personnel interfaces and operational use cases;
- a high level of examination of the potential operational, safety and organisational impacts associated with implementing a GBAS; and
- a summary of the expected improvements, disadvantages and limitations of implementing a GBAS, and alternative technologies.

The following provides examples of key considerations when performing the analysis:

- how the GBAS procedures will be designed including whether the procedures intend to overlay existing approach procedures (ILS or RNAV look alike) into the airport or are new procedures in their entirety;
- how the implementation of a GBAS aligns with the overarching Navigation strategy for the state;
- industry desire for a GBAS installation;
- whether the GBAS is intended to support autoland and guided takeoffs;
- what level of performance/service the GBAS should achieve;
- the impact of implementing a GBAS on existing ATC procedures associated with instrument approach operations including any changes to pilot interactions, phraseology, and documentation;
- how the GBAS is intended to be used within the operational environment;
- the different modes of operation for the GBAS;
- what level of GBAS status monitoring should be provided to both ATC and maintenance centres;
- what the envisaged technical support environment could look like including responsibility for maintenance and engineering support;
- different operational uses and expected responses under each use case;
- the effect on staff with implementing a GBAS and any new capabilities that may need to be developed;
- what additional training is required for staff to support the implementation of a GBAS capability;
- the limitations associated with implementing a GBAS within the State including aircraft equipage rates, technology evolution, ionosphere limitations, and support capability; and
- alternative technologies available to deliver the desired capability.

A CONOPS is a description of the characteristics of the service from the users' (such as airline staff and air traffic controllers) perspectives. The CONOPS should state the goals, strategies, policies and constraints affecting the service. It should include a clear statement of responsibilities of involved participants and stakeholders. Chapter 7.3 in ICAO Doc 9849 GNSS Manual provides reference about the elements, considerations and stakeholders involved for the development of CONOPS. The outcomes of the analysis should culminate in the development of a Concept of Operations (CONOPS) document that is distributed to all potential stakeholders including however not limited to ATC operations, maintenance, safety, and procedures design. The Concept of Operations is a useful document to enable all stakeholders to understand how the GBAS will be used within the existing ATM environment and the development of Operational Requirements.

ii. Cost Benefit Assessment

In parallel with the development of the Concept of Operations, a cost benefit assessment should be performed for understanding and determining the viability (i.e. whether it is cost effective) to install a GBAS. The cost benefit assessment should consider:

- whole of life costs associated with GBAS implementation including acquisition, operation, maintenance, and disposal costs;

- whole of industry costs including costs associated with upgrading aerodrome infrastructure, integration in existing ATM environment, staff training and equipping aircraft with the capability;
- identification of key benefits to be derived from the technology and translation into direct economic costs/benefits, such as an increase in traffic flow rates as aircraft may no longer need to be held outside of critical and sensitive areas of an ILS);
- sensitivity analysis which takes into account the effect of uncertainty on key parameters and the overall effect on the Business Case. A key uncertainty specifically for GBAS is forward equipage rates of aircraft which would directly impact usability of the technology; and
- clear articulation of the assumptions used in the cost and benefits assessment and how these impact the Business Case.

The following points identify key benefits envisaged from the implementation of a GBAS:

- One GBAS ground facility can service all runways at an airport to improve airport safety, access, and utilisation.
- GBAS can support multiple, variable approach paths to the same runway end to improve airport capacity and environmental performance with the support of complementary ATC procedures and decision support tools.
- GBAS ground facility does not have critical and sensitive areas and can increase runway throughput compared to the equivalent category of ILS if more aircraft are GLS equipped.
- ILS localiser and glide path antenna arrays are placed adjacent to the runway. In contrast, GBAS requires no equipment to be located within close proximity to the runway strip area, thereby reducing the risk of aircraft and localiser damage in overrun situations or aircraft and glide path damage due to runway excursions.
- GBAS can reduce controlled flight into terrain (CFIT), flight delays or diversions at airports which cannot install ILS on all runway ends because of terrain or other challenges.
- GBAS could reduce system support and maintenance cost in the long term, including simpler, less frequent flight inspections, compared to ILS.
- Stable and consistent approach with no vertical guidance fluctuations.
- Regarding RNP to xLS procedures, the RNP to GLS has a shorter distance from the RF leg to the final approach fix (FAF) than the RNP to ILS.

The outcomes of the analysis may be documented in a Business Case that clearly articulates the costs associated with implementation and ongoing operation, along with the envisaged benefits of the technology to the State.

iii. Technical Feasibility Assessment

As part of the planning process it is important to consider whether a GBAS installation is technically feasible at the specific airport.

The technical feasibility assessment should involve:

- a desktop analysis against siting considerations to identify suitable locations where a GBAS could be installed;

- an ionosphere threat assessment to quantify the effect of local ionospheric conditions on GBAS Integrity and Availability and whether local ionospheric conditions support the installation of a GBAS;
- a VDB coverage assessment to assess the impact of existing obstacles and terrain of VDB coverage; and
- a satellite performance assessment to assess satellite signal reception, multipath and interference.

The following provides guidance on performing each of the areas identified in the technical feasibility assessment:

- **Siting considerations**. The installation of a GBAS ground subsystem involves special considerations in choosing prospective sites for the reference receiver antennas and the VDB antenna(s). The following should be considered as part of the siting analysis:
    - proximity to existing power and communications cabling in the area;
    - soil stability and height of the surrounding terrain and the potential impact on GBAS performance;
    - proximity to aircraft movement areas and the potential impact of aircraft and vehicle movements on GBAS performance;
    - site accessibility for equipment maintenance team and security of GBAS ground facility;
    - proximity to existing infrastructure on the aerodrome and their potential impacts on GBAS performance including GPS signal reception, multipath, and VHF Data Broadcast transmission;
    - regarding multipath to the GNSS reference stations, it is necessary to assess arrangement of them so as not to be affected by the common mode errors;
    - the location of environmental sensitive areas (e.g. critical wildlife habitat, wetlands, contaminated soil);
    - future developments on the aerodrome and their potential impact on GBAS performance and location;
    - potential infringements of the Airport Height Restriction Surfaces surrounding the airport;
    - the location of the VDB antenna should ideally maintain visual line of sight to the Decision Height, Runway Thresholds and along the runway (if the GBAS is intended to support autoland and guided takeoffs); and
    - the likelihood of intentional or unintentional Radio Frequency Interference impacting GPS signal reception.
- **Satellite Performance**. A satellite signal performance assessment should be performed at each site identified for installation of GBAS ground facility as part of the technical feasibility analysis to quantify:
    - satellite signal reception at each location;
    - the extent of satellite multipath and noise at the location; and
    - the extent of radio frequency interference in the environment and potential impact on satellite signal reception.

  This could involve the short term deployment of a dual frequency satellite receiver, antenna, and data collection device.

- **Ionosphere**. There are two effects of the ionosphere on GBAS, which are the ionospheric delay and scintillation. Resulted characteristics and severity of both impacts are different in locations (especially in the magnetic latitude) and seasons. It is also known that they change depending on the solar activity, which has an approximately 11-year cycle.

    - Although user's range error component of the ionospheric delay is almost removed under nominal condition using the GBAS correction messages, it could increase if there is a large spatial gradient between the GBAS ground subsystem and the user.
    - The ionospheric scintillation effect on ranging signals, which is frequent loss of lock, is caused by ionospheric irregularities with ionospheric disturbances. It could result lower availability of the GBAS performances.

  In the GBAS safety assessment, "nominal" and "anomalous" ionosphere conditions should be defined together with system architecture and safety design of GBAS ground subsystem. Under the former nominal condition, user is protected by the GBAS differential correction messages with an integrity parameter for ionospheric error. In contrast, user is not bounded by the parameter under the latter anomalous condition. Therefore, it is necessary to detect and exclude such erroneous ranging sources with appropriate integrity monitors at the GBAS ground subsystem. Note that the targeted horizontal scale of the disturbances is within a few tens of kilometres.

    - Concerning the nominal condition, the Equatorial anomalous is a dominant factor to determine background spatial gradient of the ionospheric delay in the low magnetic latitude region. It has seasonal variation and dependency on the solar activity. Therefore, the vertical ionospheric gradient σ_{vig}, which is an integrity parameter included in the GBAS messages to calculate the user's protection levels, should be determined, considering these characteristics based on sufficient period of observational data.
    - As an example of the ionospheric anomalous condition, plasma bubble which is disturbance with ionospheric density depletion produces steep ionospheric spatial gradients and scintillation on GNSS signals. It frequently occurs after sunset in high solar activity periods. For the safety system design of the GBAS ground subsystem, it is necessary to define ionospheric threat model which describes the ranges to assess the ionospheric effects on the GBAS. Regarding the range definition, underestimation exposes users to unsafe condition whereas overestimation significantly degrades system availability. Detailed assessment is described in another guidance document of GBAS/SBAS safety assessment guidance related to anomalous ionospheric conditions.

- **VDB coverage assessment**. The ICAO Annex 10, Volume 1, Standards and Recommended Practices stipulate to minimum Approach Service Volume. As part of the technical feasibility assessment a theoretical coverage analysis should be performed to determine the likelihood that VDB coverage requirements will be met. The coverage can be performed using commercially available radio coverage modelling software.

The following document provides useful information for siting a GBAS installation:

- Siting Criteria for Ground Based Augmentation System (FAA Order 6884.1)

iv. VDB Frequency Application and Assignment

The GBAS makes uses of GNSS to provide precision landing with benefits of enhancing safety and operational efficiency. In a typical GBAS installation, a VHF data broadcasting (VDB) radio shall be installed at the vicinity of the airport to broadcast the correction message to the aircraft for the provision of precision approach service. According to the ICAO SARPs, GBAS operates in the frequency band 108 – 117.975 MHz. The lowest assignable frequency is 108.025 MHz and the highest assignable frequency is 117.950 MHz. The frequency spectrum and channel plan of the VDB is the same as the VOR and ILS LOC.

With reference to ICAO Doc 9718 Vol. II, the channel spacing for a VDB shall have minimum of 1 MHz channel spacing from any existing VOR, ILS LOC or other VDB within a defined range, which is the range where no interference is anticipated. Based on this range and the plus or minus 1 MHz channel spacing requirement, a VDB frequency must be assigned so that there will be no harmful interference from and to other VHF sources including VOR, ILS LOC, VHF COM, and FM broadcast. As such, States should take a holistic approach for frequency assignment to GBAS VDB, VOR, and ILS LOC.

There are two aspects of consideration in frequency assignment and deployment for GBAS VDB:

(a) Same-airport compatibility
(b) Airport-to-airport compatibility

The same-airport compatibility refers to the compatibility with VHF facilities in the same airport where the GBAS is installed. It involves analysis on impact/interference among VHF facilities on aircraft, GBAS VDB facilities and other airport VHF facilities, including the consideration of minimum separation of VDB transmitter antenna from aircraft to avoid saturation of VHF receiver on aircraft. It would mainly be the matter of siting criteria for GBAS VDB ground facilities and is not relevant to frequency coordination.

The airport-to-airport compatibility is the frequency compatibility of VDB with other VHF facilities outside the airport where the GBAS is installed. The coordination would not only be within the State/Administration but should only work out with neighboring States/Administration associated with the Designated Operational Coverage (DOC) to ensure no adverse impact due to any interference from and to other VHF sources aforesaid. Such consideration is described in the ICAO Handbook on Radio Frequency Spectrum Requirements for Civil Aviation (Doc 9718) Vol. II, with the following principles:

(a) The ratio of the desired-to-undesired power (D/U ratio) must be greater than a threshold.
(b) The D/U ratio threshold is defined as a function of the frequency separation, but it is also a function of the power input to the receiver. It is -60 dB for 1 MHz separation with sufficiently low power.
(c) The D/U ratio can be assessed at the edge of the declared operational coverage where the desired power will be minimum.
(d) The power of signals can be estimated as per the ITU propagation curve (ITU-R Recommendation)

Assuming that the radius of the DOC is 23 NM which is the nominal value for GBAS, the above criteria are safely satisfied when the frequency separation is 1 MHz or more and the geographical separation is 30 NM or more. Furthermore, a real shape of the service volume of the GBAS could be considered, because the potential interference may occur outside the intended service volume. It should be noted that the minimum service volume as defined in the ICAO Annex 10 is not a circular area but is a "keyhole" shape (see ICAO Annex 10 Attachment D Figure D-5).

v. GBAS Solution Selection

Once a preliminary site has been identified, there are a number of different GBAS solutions available in the market to support the delivery of a GLS service. Careful consideration and selection of the most appropriate solution is essential to ensure that the expected benefits are realised. The following provides high level guidance when selecting a GBAS product:

- States should ensure that the product conforms with ICAO Annex 10, Volume 1 Standards and Recommended Practices for a GBAS and that any non-conformances have been appropriately assessed and accepted;
- States should consider whether the proposed solution has previously been certified by another State. Previous certification may allow States to leverage the existing certification evidence to expedite the regulatory approvals process and simplify any developmental processes;
- Nominally certification involves demonstration that the product meets a particular specification published by a State. If States intend on utilising an existing product that has previously been certified by another State, then States should assess:
    - if the specification used to develop the certified GBAS product is suitable for use in the local region. This should involve a comprehensive analysis of each of the requirements contained within specification to determine the extent of applicability and if determined to be either partially applicable or not applicable, alternative requirements should be developed.
    - any waivers and deviations to the specification used to develop the certified GBAS product and whether those waivers and deviations are acceptable for the local region.
- States should consider the development pathway for the product and whether the development pathway aligns with the intended operational objectives;
- States should consider developing a set of site specific requirements that are unique to the particular location at which the solution is intended to be deployed. Key site specific requirements may include:
    - Operational Requirements (key ATC requirements)
    - Legislative requirements
    - Work Health & Safety requirements
    - Civil Works specific requirements
    - Monitoring and integration requirements
    - Installation specific requirements
    - Site specific requirements
    - Maintenance requirements.
- when selecting a GBAS solution, States should also consider who will be responsible for the design, installation, operation and ongoing maintenance of the facility and ensure that any applicable requirements have been developed and integrated into a Statement of Work

- States should establish appropriate assessment criteria against which all GBAS products will be assessed.

vi. Site Deployment

Once a product has been selected, key activities to be performed include:

- **Site design**. The site design may involve:
  - finalising the installation location for the GBAS. This should include addressing any unique product requirements pertaining to the siting of the GBAS. As an example, some manufacturers may impose restrictions on the proximity of the antennas to runway/taxiway or distance to the furthest Decision Height.
  - developing the Civil Works design and obtaining approvals that the drawings comply with local legislative requirements.
  - integration design (how the GBAS will integrate with existing ATM systems).
- **Equipment installation**. This will primarily involve performing the Civil Works in accordance with the approved design drawings, installation of communications and power infrastructure, and installation of the GBAS equipment in accordance with the manufacturers manuals.
- **Integration with existing Air Traffic Management Systems.** This will primarily involve integrating the GBAS with other ATM systems including providing GBAS status monitoring to Maintenance and Operations.
- **Verification Activities**
  - **Factory Acceptance Testing**. Prior to the installation of the GBAS, States may elect to perform a Factory Acceptance Test to verify that the product conforms with the State's specification.
  - **Site Acceptance Testing.** Post installation, Site Acceptance Testing will nominally involve verifying the system is performing as per the requirements, has been installed in accordance with the approved documentation and manufacturers manuals.
  - **Flight Inspection.** Prior to Commissioning a Flight Inspection should be completed which is more fully addressed in Section ix.
- **Operational Test & Evaluation.** Prior to Commissioning the GBAS for full operational use, States may elect to perform an Operational Test & Evaluation program. The Operational Test & Evaluation program may involve independent monitoring of the GBAS signal in space and/or approved aircraft operators flying GLS approaches in controlled conditions to validate the service is operating as intended.

vii. Airport Height Restriction Plan Amendment

In order to protect the GBAS ground segment from unauthorised developments or intrusions that may impact on the performance of the GBAS, a comprehensive protection area should be established around the GBAS site. The area should be designed to protect:

- GPS satellite reception and tracking at each of the Reference Receivers
- VDB coverage particularly within the Approach Service Volume for each runway.

Depending on the location of the GBAS, restrictions may additionally be imposed on vehicle and/or aircraft movements within the vicinity of the GBAS. These will be site dependent and should be established and verified as part of site deployment.

The following provide examples of protection areas implemented by other States.

- FAA Order 6884.1 – Siting Criteria for Ground Based Augmentation System (GBAS)

viii. Operational Considerations

When deploying a GBAS it is important that States consider changes to existing practices for ATC and procedures design staff. The following provides guidance on key areas to consider with the introduction of a GBAS:

- any changes to sectorisation or airspace (introduction of a first of type precision to a runway or extension of the GBAS Approach Service Volume may require airspace changes)
- any changes to practices for processing traffic
- any changes to phraseology
- any changes to separation standards
- any changes to the information provided to pilots
- any changes to existing documentation including any local instructions or training documentation
- changes to workstations and equipment
- changes to Human Machine Interfaces.

ix. GBAS Instrument Flight Procedure Design

GBAS Instrument Flight Procedures, also named as GLS, are designed as per the provisions of ICAO DOC 8168 VOL II (Chapter 6 in Section 3 of Part III) by authorized procedure designers using available tools with latest survey reports and Obstacle & Terrain data. The two key outputs of the Procedures Design process are the corresponding Approach Chart and Final Approach Segment (FAS) Data Block. The FAS Data Block contains the information detailed within ICAO Annex 10, Volume 1 defining the final approach path. Validation of the parameters contained within the FAS Data Block is critical to assuring the safety of the approach. Flight Validation may be carried out for each GLS procedure either on a simulator or actual flight.

The GLS procedure design criteria defined in Doc 8168 Vol-II are based on ILS criteria and are related to the ground and airborne equipment performance and integrity required to meet the operational objectives described in Annex 10.

The procedure from en-route to the GLS final approach segment and in the final missed approach phase conforms to the general criteria. The differences are found in the physical requirements for the GLS precision segment which contains the final approach segment as well as the initial and intermediate phases of the missed approach segment. These requirements are related to the performance of the GBAS system.

RF turn to the final approach course - The intermediate approach segment may incorporate a PBN route ending with a radius-to-fix turn to the final approach course. In this case, the RF turn shall terminate at a waypoint located on the final approach course. The position of this waypoint is considered as the point of localizer interception.

The FAS data block is prepared by the procedure designer and the accuracy of the path is dependent on the accuracy and integrity of the original data on the runway and calculations carried out by the designer. The final approach path parameters are designed using geodetic and geometric calculations and the parameters are formatted into a FAS data block in electronic media with a cyclic redundancy check (CRC). To insure the integrity of the data, the complete block is transferred electronically to users for inclusion of the path data in the GBAS system for transmission to user airborne systems.

A complete description of the FAS data block is included in Doc 9368, Instrument Flight Procedures Construction Manual, Attachment C.5, along with an example of the process and product.

The current ILS Collision Risk Model (CRM) may be used to arrive at an optimum OCA/H until specific GBAS distributions for the existing CRM are developed.

Glide path verification check - A fix at the FAP is necessary so as to permit comparison between the indicated glide path and the aircraft altimeter information.

Validation of GLS procedures could take reference to relevant information stipulated in ICAO Doc 9906 Volume 5.

x. Flight Check

A Flight Check can be considered to address the performance of the GBAS (Flight Inspection) and also the flyability of the approach procedure (Flight Validation).

A Flight Inspection is nominally performed as part of Site Acceptance Testing and prior to Commissioning. Successful completion of the Flight Inspection is a critical to assure that the system is operating as intended and any restrictions on the use of the GBAS have been appropriately identified and promulgated.

The primary intention of conducting a GBAS Flight Inspection is to verify that VHF Data Broadcast (VDB) field strength requirements are met throughout the GBAS Approach Service Volume defined in the ICAO Annex 10, Volume 1 Standards and Recommended Practices and identify any interference or degradation to the GBAS signal in space.

Flight Inspection of GBAS additionally serves as a means to conduct a Position Domain Functional Check and a check of the Final Approach Segment (FAS) Data. The Position Domain Functional Check however is not intended to provide a statistical confidence level of the position measurement as GNSS errors change over time as detailed in ICAO Annex 10, Volume 1.

Some States additionally include a requirement to Flight Check GBAS at routine intervals. The intervals range from 9 months to 60 months and is at the discretion of the State. The primary intention of routinely Flight Inspecting a GBAS is to detect changes to the environment surrounding the site that may impact on VDB coverage. Additionally routine Flight Inspection serve as a means to validate that the Airport Heigh Restriction Plan is appropriately protecting the GBAS from unauthorised intrusions and developments.

Further guidance material on Flight Inspecting the GBAS is available in the following documents:

- ICAO DOC 8071, Volume 2, Testing of Radio Navigation Aids

Flight validation of the approach procedure may also be required to confirm that the procedure is flyable for all aircraft categories that will use the GBAS for precision approaches.

xi. Logistics Support

In order to support the GBAS post implementation, States should ensure that appropriate Support Systems have been established to provide continuous maintenance and operation. This may include:

- **Maintenance Support**. Maintenance Support should be performed by appropriately trained qualified and experience staff or delivered by the manufacturer. Maintenance Support may encompass regular performance inspections of the GBAS ground equipment and support infrastructure to verify the GBAS is operating in accordance with prescribed performance requirements and corrective maintenance activities. The Maintenance Support environment should ensure that there is an adequate level of spares available to meet Availability requirements and appropriate systems in place to record maintenance related issues. Timeliness of the response to all maintenance requirements should also be addressed.
- **Engineering Support**. Engineering should be performed by appropriately trained, qualified and experience staff or delivered by the manufacturer. Engineering Support may encompass configuration management of the system, investigation of complex faults and failures, ongoing monitoring of GBAS performance and system enhancements.
- **Supply Support**. Supply Support should ensure that there is adequate manufacturer support in place for ongoing logistics support including investigation of complex faults and failures, repair of equipment, and supply of additional spares.

xii. Training

The introduction of GBAS in any State represents a significant change for aviation, so it requires new approaches to regulation, provision of services and operation of aircraft, and personnel training is the key for the success of implementation.

A Training Needs Analysis should be completed by States to identify the training needs for all stakeholders involved in the operation, use and maintenance of the GBAS. Stakeholders that should be included within the analysis include ATC staff, maintenance staff, engineering staff, pilots, and procedures designers.

The Training Needs analysis should:

  - identify of the impact of GBAS implementation to the stakeholder and a determination of any delta training required;
  - include an analysis of the skills and knowledge required to install, certify, operate and/or maintain the GBAS ground facility and GBAS based services; and
  - include training resources, methods and delivery requirements.

The following provides examples of training delivered for GBAS by other States:

- **General Awareness training.** General awareness involve training on the overview of GNSS and Augmentation systems, principles of operation of a GBAS, differences between an ILS and GBAS based precision approach, the limitations and advantages of a GBAS, and should be provided to all stakeholders.
- **ATC.** ATC staff should be provided with a briefing on the GBAS, changes to local instructions as a result of the introduction of a GBAS, changes to the information contained within a Flight Plan, any changes to endorsements/ratings, interpretation of GBAS monitoring indications, and training on any new systems introduced to support delivery of a GLS approach capability.

- **Regulators.** Regulators should be provided with general awareness training and the training pertaining to applicable SARPs for updating the regulation to include GBAS operations.
- **Maintenance**. Staff responsible for maintaining the GBAS should be provided with training on the fundamental principles of operation of a GBAS, specific equipment, operation of the equipment and maintenance practices for the equipment including routine maintenance activities to be performed and procedures for investigating of faults and failures. States may elect to develop a set of GBAS competency criteria against which the competency of maintenance staff would be assessed.
- **Engineering.** Staff responsible for Engineering Management of the GBAS ground facility should be provided with training on advanced GBAS concepts, configuration management of the GBAS, and complex fault analysis.
- **Pilot**. Pilot training will be driven by the airline and specific aircraft type. Pilot training may involve a differences course between GBAS and ILS and corresponding simulator training.
- **Procedures Design.** Instrument Flight Procedure Designers may be provided with supplementary training on the differences between GBAS and ILS and information contained within a Final Approach Segment (FAS) data block.

xiii. Development of Regulations Related to GBAS for Aviation

It is necessary to have a common understanding among all the relevant aviation stakeholders regarding the GBAS implementation and GBAS based services/procedures being utilized in civil aviation.

Regulations related to GBAS in civil aviation:

- Any GBAS ground facility installed at and/or in the vicinity of airport shall not be used for the provision of GBAS based services unless certified by the regulatory authority of the State.
- Any GBAS based service/procedure shall not be put into use for civil aviation purposes unless approved by the regulatory authority of the State.
- The details of GBAS ground facility installed at and/or in the vicinity of airport including GBAS based service/procedure shall be published in AIP.
- Any aircraft shall not utilize the GBAS based service/procedure unless the avionics requirement in terms of GBAS receiver equipage, pilot training requirements etc. are being met, as prescribed by the regulatory authority of the State.
- On-board GBAS receiver shall be certified by the regulatory authority of the State.
- The GBAS service provider shall carry out system check and operational performance monitoring on a continuous basis. The reports in respect of accuracy, integrity, availability, and continuity should be prepared and shared with the regulator on a periodic basis. Any major degradation in service or breach of terms and conditions may lead to withdrawal/cancellation of certificate/approval.
- The State may develop Inspection checklist for the purpose of certification of GBAS ground facility.
- The State may develop compliance checklist for the purpose of granting approval to GBAS based services/procedures.
- The State should develop the certification and re-certification methodology including revocation of certificate for GBAS ground facility, stating the certification process, regulatory requirements, period of validity, terms and conditions, if any.
- The State should also develop the approval and withdrawal process for GBAS based services/procedures.

An important issue during implementation of GBAS is certification and operational approvals that are dependent upon the State's national regulations. The regulator should be involved right from the first phase of GBAS implementation process (i.e. Operational Need Analysis) along with the other stakeholders for smooth conduct of certification process.

The common steps in certification are: System Design Approval, Facility Approval and Operational Approval.

System design approval (SDA) refers to the certification of the system as a product. Each state may have a procedure to do all the SDA or validate the SDA done by another country.

Facility approval refers to the certification of the installation, with the compliance with all the requirements of the product installed in a specific location and condition.

Operational approval refers to proper operation, and involves existence of regulations, personnel training and all operational process defined and documented.

All the three approvals should follow six phase certification process:

- **Phase One: Pre-Application.** The aerodrome operator and relevant stakeholders should convene a meeting with the regulator (pre-application meeting) for ascertaining all the requirements to be met, during the approval process.
- **Phase Two: Formal Application.** The operator should submit the formal application to the regulator, accompanied with all the relevant documentation.
- **Phase Three: Review of Documentation.** The regulator should evaluate the documentation to determine their conformance with ICAO SARPs and national regulations. As a result of this review and evaluation, the regulator may accept, suggest certain changes or reject the formal application along with the documentation.
- **Phase Four: Inspection and Demonstration.** The regulator should carry out the physical inspection of GBAS ground facility and demonstration of intended capability including simulator and/or flight trial, if required. Once the regulator accepts or approves the changes made based on documentation review and the satisfactory outcome of Inspection and Demonstration, the relevant stakeholders should:
  (a) provide the respective training to its personnel; and
  (b) implement the operational demonstration.
- **Phase Five: Approval.** Once all the aforementioned steps have been completed satisfactorily, the regulator should issue the relevant approval.
- **Phase Six: Post-Implementation Review.** The Post-implementation review should be carried out and the system and operational performance should be monitored on a regular basis. The reports in respect of accuracy, integrity, availability, and continuity should be prepared and shared with the regulator on a periodic basis. Any major degradation in service or breach of terms and conditions may lead to withdrawal/cancellation of certificate.

xiv. Safety Assessment and Certification

The Safety Assessment and Certification process should fundamentally demonstrate that the Service provided will be acceptably safe during and after the implementation of the GBAS. Early engagement with the Regulator on the approach to certification and Regulatory involvement in certification activities is critical to achieving a successful outcome.

The Safety Assessment process could comprise of two key components:

- **System Safety**. This should demonstrate that the system as designed and operated in accordance with approved practices is safe. Previous certification may allow States to leverage the existing certification evidence to expedite the System Safety assessment process
- **Service Safety**. This should demonstrate that the Certified System installed within the local environment will be acceptably safe. This may include:
  - demonstration that the local ionosphere conditions are adequate to support the intended level of service
  - demonstration that there has been an adequate level of assurance that critical GBAS data has been validated
  - demonstration that local regulations and requirements have been met.

The key elements of the certification argument could comprise of:

- **Concept Defined.** Demonstration the concept of operations has been adequately defined and documented. This should address the question how will the GBAS integrate and operate within the states Air Traffic Management System.
- **Safety Assurance.** Demonstration that safety assurance activities have been conducted for the system as a whole and that identified hazard controls have been incorporated into the design and implementation.
- **Design and Implementation.** Demonstration that the system has gone through adequate system design and implementation process. Demonstration that the design and implementation meets legislative requirements and conforms with ICAO SARPS.
- **Support Systems.** Demonstration that the necessary sustainment systems are in place, which are adequately defined with acceptable controls in place to reduce the level of risk to As Low As Reasonably Practicable.
- **Operational Testing.** Demonstration that Operational Testing has been adequately defined, completed and that the level of risk is acceptable. Any lessons learnt from Operational Testing have been integrated into CAT-I operations.
- **CAT-I Operations.** Demonstration that CAT-I landing operations are defined, Support Systems updated and the level of risk acceptable.

Once all of the elements have been addressed, a comprehensive Safety Case can be developed and presented to the Regulator.

xv. Post Implementation Review

Subsequent to the Commissioning of a GBAS installation and after an appropriate period of operation States should consider conducting a Post Implement Review. The Post Implementation Review should involve the review of:

- service requirements and whether the GBAS has met those Service Requirements
- operational practices for the GBAS
- implementation process and areas for improvement
- hazards associated with the operation of the GBAS and whether existing risk assessments remain valid
- any occurrences or system related issues
- any safety related issues

- whether the safety benefits envisaged from the implementation of the GBAS have been met

6. POST-IMPLEMENTATION ACTIVITIES

a. Operation and Maintenance Activities

Subsequent to the implementation of the GBAS, States should consider conducting a Post Implementation Review. The Post Implementation Review should:

- provide assurance that the residual safety risks associated with the operation of the GBAS continue to be managed to As Low As Reasonably Practicable (ALARP)
- lessons learnt from the initial operating period are captured
- identify any issues experienced and action to address those issues
- any outstanding tasks for activities within the Safety Case have been appropriately addressed
- validate that assumptions are still applicable

States will be required to perform maintenance activities on a routine basis to verify the GBAS is operating within the required standards. ICAO DOC 8071, Volume 2, presents guidelines on recommended ground and airborne testing practices. Examples of maintenance activities may include:

- verifying whether the VDB transmitter frequency, VDB receiver Frequency, and VDB transmitter output Power are within tolerance
- verifying whether any spurious emissions emanating from the VDB transmitter are within tolerance
- verifying whether power in adjacent channels is within tolerance
- Verifying whether the antenna Voltage Standing Wave Ratio is within tolerance
- checking the functionality of any GBAS monitoring systems to Air Traffic Control or Maintenance Centres
- reviewing Event Logs for any new fault conditions
- verifying functionality of any redundant power systems
- checking for any signs of damage or corrosion to the supporting infrastructure
- Routine Flight Inspections to verify VDB coverage. The requirement for and frequency of ongoing Routine Flight Inspections is at the discretion of the State.

Additionally, States should continuously monitor for changes to the satellite constellation (e.g. satellite maintenance activities) and assess the impact of constellation changes on the performance of the GBAS, specifically on availability. Furthermore, States should continuously monitor for changes to the environment surrounding the GBAS, including new developments and vegetation growth, to ensure that impacts to GBAS performance are minimised.

b. Performance Indicators

States should assess the performance of the GBAS against the Performance Indicators established in regular basis during the implementation and post-implementation phases. States may also regularly review the effectiveness of performance indicators established in evaluating the performance of GBAS.

Appendix 1 – Terminologies and Definition

ATC	Air Traffic Control
ATM	Air Traffic Management
CAT-I	Category I
CONOPS	Concept of Operations
CRC	Cyclic Redundancy Check
CRM	Collision Risk Model
FAA	Federal Aviation Administration
FAF	Final Approach Fix
FAP	Final Approach Point
FAS	Final Approach Segment
GBAS	Ground Based Augmentation System
GNSS	Global Navigation Satellite System
ICAO	International Civil Aviation Organization
ILS	Instrument Landing System
RNAV	Area Navigation
RNP	Required Navigation Performance
SARPS	Standards and Recommended Practices
SDA	System Design Approval
VDB	VHF Data Broadcast
VHF	Very High Frequency

_ _ _ _ _ _ _ _ _ _ _ _ _

Appendix 2 – Reference

1. *Relevant ICAO documents covering different aspects in GBAS implementation:*
    a. *Global Strategy – Global Air Navigation Plan (Dec 9750)*
    b. *Regional Strategy – Asia/Pacific Seamless ATM Plan*
    c. *General Concept - Global Navigation Satellite System (GNSS) Manual (Doc 9849)*
    d. *System Requirements and Testing*
        i. *Annex 10 Vol I – Radio Navigation Aids*
        ii. *Doc 8071 Vol II – Testing of Satellite-based Radio Navigation Systems*
    e. *Procedure Design and Validation*
        i. *Doc 8168 Vol II – Construction of Visual and Instrument Flight Procedures*
        ii. *Doc 9906 Vol V – Validation of Instrument Flight Procedures*
    f. *Operation*
        i. *Doc 8168 Vol I – Flight Procedures*
        ii. *Doc 9613 – PBN Manual*
        iii. *Doc 9849 – GNSS Manual*
        iv. *Dec 4444 – Air Traffic Management*
        v. *Doc 9734 – Safety Oversight Manual*
        vi. *Doc 9859 – Safety Management Manual*
    g. *Ionosphere*
        i. *GBAS Ionospheric Threat Model for APAC Region (APAC)*
        ii. *GBAS Safety Assessment Guidance Related to Anomalous Ionospheric Conditions (APAC)*
        iii. *Ionospheric Effects on GNSS Aviation Operations (ICAO NSP)*

2. *Relevant documents published by international organisations / States / Administrations relevant to GBAS implementation:*
    a. *RTCA DO-246E Change 1 - GNSS-Based Precision Approach Local Area Augmentation System (LAAS) Signal-in-Space Interface Control Document (ICD)*
    b. *RTCA DO-253D Change 1 - Minimum Operational Performance Standards (MOPS) for GPS Local Area Augmentation System (LAAS) Airborne Equipment*
    c. *EUROCAE ED-114 - Minimum Operational Performance Standards (MOPS) for GBAS Ground Facility*
    d. *FAA Order 6884.1 - GBAS Ground Facility Siting Criteria*
    e. *FAA-E-3017 - Non-Fed LAAS Specification*

_ _ _ _ _ _ _ _ _ _ _ _ _

Appendix 3 – Experience Sharing by States/Administrations

(a) Airservices GBAS Implementation Journey

2021 Third meeting of GBAS-SBAS Implementation Task Force (GBAS-SBAS ITF/3)
Video Teleconference
27-28 September 2021

AIRSERVICES GBAS CERTIFICATION JOURNEY

Ritesh Kapoor
ritesh.Kapoor@airservicesaustralia.com

AIRSERVICES GBAS JOURNEY

NOTE: TIMELINE NOT TO SCALE

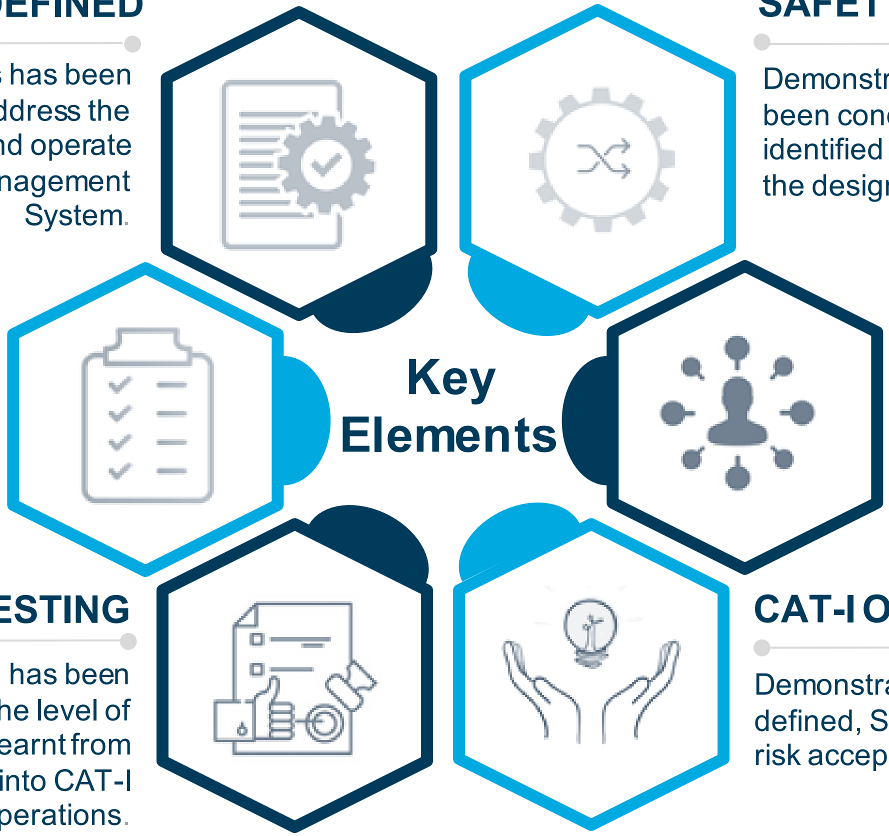
ACRONYMNS

FAA – Federal Aviation Administration
SDA – System Design Approval
CASA – Civil Aviation Safety Authority

TO CERTIFY GBAS FOR USE IN AUSTRALIA, AIRSERVICES NEEDED TO DEMONSTRATE:

“The Air Traffic Management System will be acceptably safe during and after the implementation of the Ground Based Augmentation System to support CAT-I landing operations”

KEY ELEMENTS OF THE CERTIFICATION ARGUMENT



CONCEPT DEFINED

Demonstration the concept of operations has been adequately defined and documented. Address the question how will the GBAS integrate and operate within Airservices existing Air Traffic Management System.

SAFETY ASSURANCE

Demonstration that safety assurance activities have been conducted for the system as a whole and that identified hazard controls have been incorporated into the design and implementation.

DESIGN AND IMPLEMENTATION

Demonstration that the system has gone through adequate system design and implementation process. Demonstration that the design and implementation meets legislative requirements and conforms with ICAO SARPS.

SUPPORT SYSTEMS

Demonstration that the necessary sustainment systems are in place, which are adequately defined with acceptable controls in place to reduce the level of risk to As Low As Reasonably Practicable.

OPRERATIONAL TESTING

Demonstration that Operational Testing has been adequately defined, completed and that the level of risk is acceptable. Any lessons learnt from Operational Testing have been integrated into CAT-I operations.

CAT-I OPERATIONS

Demonstration that CAT-I landing operations are defined, Support Systems updated and the level of risk acceptable.

CONCEPT DEFINED

A dedicated GBAS Concept of Operations was developed to articulate how the GBAS would be used in the current Air Traffic Management environment. The Concept of Operations was critical to developing Operational Requirements and deriving technical requirements.

KEY CONCEPTS

Operational Use

The introduction of GLS approaches should result in minimal changes to existing pilot and ATC interactions and should be fully integrated with existing airport operations (e.g. Parallel runway operations).

Service Levels

The GBAS should conform with ICAO Annex 10, Volume 1, Standards and Recommended Practices and replicate existing CAT-I ILS service levels.

Procedures Design

GLS procedures designed to be ILS and/or RNAV(GNSS) look-alike to fit in with existing ATC procedures.

ATC Procedures

Introduction of GBAS should require minimal changes to ATC procedures and phraseology. GBAS status indications will be provided to Tower and Terminal Control executive positions.

SAFETY ASSURANCE ACTIVITIES COMPLETED

APPLICATION OF AIRSERVICES SAFETY MANAGEMENT SYSTEM TO THE GBAS IMPLEMENTATION.

HAZARD IDENTIFICATION AND ANALYSIS

- Hazard identification and analysis workshops undertaken to identify, analyse and develop controls for **hazards associated with integrating the GBAS into Australian airports**
- Key stakeholders included Operations, Engineering, Procedures Design, Airlines, Regulator and Maintenance.
- Eight high level hazards identified
- Three operational hazards accepted due to the low probability of occurrence

HUMAN FACTORS ASSESSMENT

- SLS-4000 GBAS has a number of computer based interfaces with operational personnel, either ATC or maintenance
- Human Factors analysis undertaken to demonstrate systems were fit for purpose

WORKPLACE HEALTH AND SAFETY

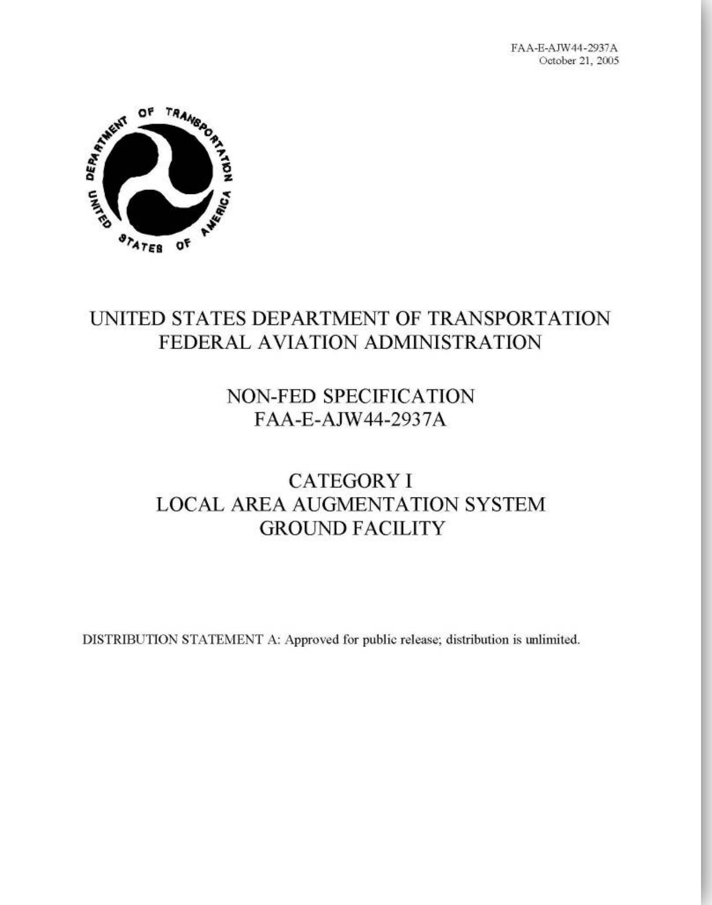
- Workplace health and safety impacts, due to the installation of the system, ongoing occupancy of the GBAS shelter
- Hazards identified, assessed and controlled through the Work Health & Safety assessments

IDENTIFIED CONTROLS WERE INTEGRATED INTO THE GBAS DESIGN AND IMPLEMENTATION AND VERIFIED TO BE MET IN THE SAFETY CASE

DESIGN AND IMPLEMENTATION – CERTIFIED PRODUCT

KEY COMPLIANCE WITH REGULATOR SPECIFICATION AND STANDARDS

- FAA published a Non-Federal Specification for a Category I Local Area Augmentation System Ground Facility (FAA-E-AJW44-2937A which was later updated to FAA-E-3017)
- Traceable to ICAO Annex 10, Volume 1 Standards and Recommended Practices for GBAS
- Honeywell SLS-4000 GBAS was found to be compliant with the FAA Specification with approved waivers and deviations
    - **Honeywell SLS-400 GBAS achieved FAA System Design Approval (SDA)**
- SLS-4000 GBAS product developed to RTCA DO-278 and DO-254 and System Safety Processes complaint with ARP-4754 and ARP-4761.



FAA-E-AJW44-2937A
October 21, 2005

UNITED STATES DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

NON-FED SPECIFICATION
FAA-E-AJW44-2937A

CATEGORY I
LOCAL AREA AUGMENTATION SYSTEM
GROUND FACILITY

DISTRIBUTION STATEMENT A: Approved for public release; distribution is unlimited.

DESIGN AND IMPLEMENTATION – APPLICABILITY IN AUSTRALIA

FOCUS FOR AIRSERVICES IS ON CERTIFYING A PRODUCT DESIGNED FOR THE USA FOR USE IN AUSTRALIA

FAA SPECIFICATION

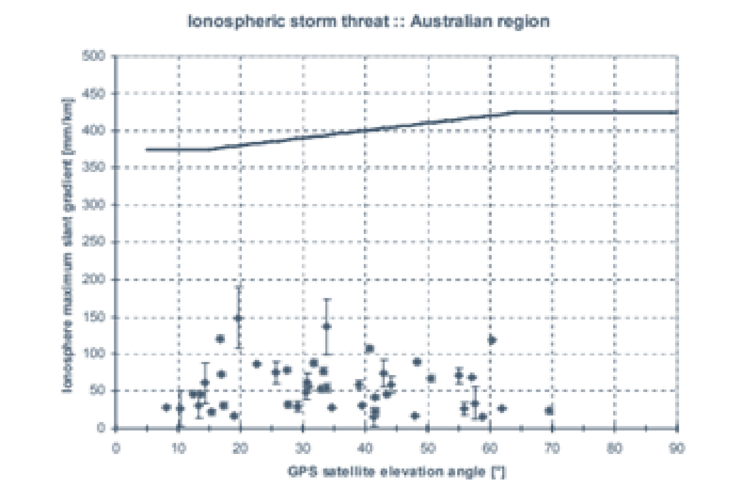
IS THE FAA SPECIFICATION SUITABLE FOR USE IN AUSTRALIA? *MAJORITY APPLICABLE*

- Each requirement in the FAA Specification reviewed, assessed and marked as "Applies in Total", "Partially Applies" or "Does Not Apply" for Australia
- Primary differences were in local infrastructure requirements (e.g. electrical, structural, siting standards)
  - these requirements were integrated into a local requirements baseline
- Independent assessment of the FAA waivers and deviations to the Specification
  - all deviations and waivers found to be acceptable in Australia

IONOSPHERE THREAT MODEL

IS THE THREAT MODEL SUITABLE FOR USE IN AUSTRALIA? *YES*

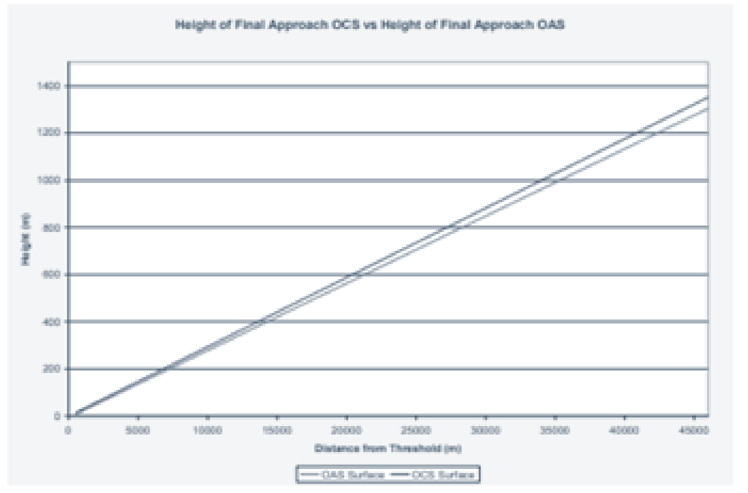
Independent study concluded *"All observations of anomalous ionospheric gradients in the Australian mid-latitude region in this study fell within the parameters of the ionospheric threat model integrated into the CONUS certified Smartpath GBAS design"*



ERROR CONTAINMENT

DO OAS METHDOLOGIES WHOLLY CONTAIN THE MAXIMUM IONOSOHPERE INDUCED ERROR IN VERTICAL POSITION? *YES*

"existing OAS methodologies, which are used for ILS protection, protects against the worst case aircraft height for both approach and missed approach phases of flight."



ACRONYMNS

CONUS – Conterminous United States
OAS – Obstacle Assessment Surface

airservices

DESIGN AND IMPLEMENTATION – REQUIREMENTS BASELINE

DEVELOPING LOCAL REQUIREMENTS

- A dedicated set of requirements was developed for each site focusing on unique requirements in Australia
- These included:
  - Operational Requirements (ATC)
  - Legislative requirements (state and federal)
  - GBAS monitoring requirements
  - Installation specific requirements
  - Site specific requirements
  - Maintenance requirements
- All requirements were consolidated into a single requirements baseline for each site

EXAMPLE: AUSTRALIAN SPECIFIC REQUIREMENTS

1 *"All electrical installations shall comply with AS/NZS 3000 (wiring rules) in particular, but not limited to Appendix K in relation to the installation, alteration, repair, maintenance and testing of high voltage electrical installations (Electricity Safety (Installations) Regulations 2009)."*

2 *"The GBAS System shall have a status of NOT OK when any of the following conditions are met:*
a) GBAS is in NOT AVAILABLE mode as defined in FAA-E-3017 section 3.1.4.2;
b) GBAS is in TEST mode as defined in FAA-E-3017 section 3.1.4.2;
c) A failure of the Monitoring System;
d) A Predicated Constellation Alert; or
e) An Actual Constellation Alert."

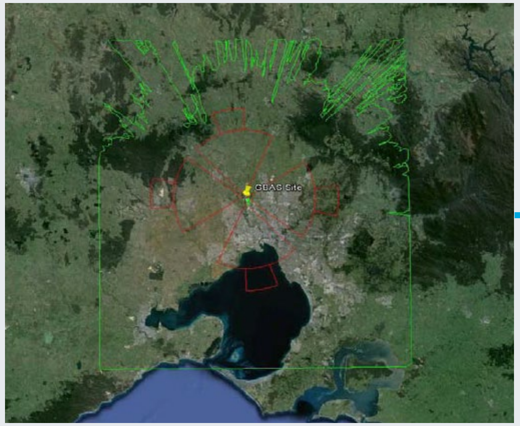
3 *"The GBAS shall meet the general safety requirements of AS/NZS 60950.1:2003 (Information technology equipment - Safety Part 1: General requirements)."*

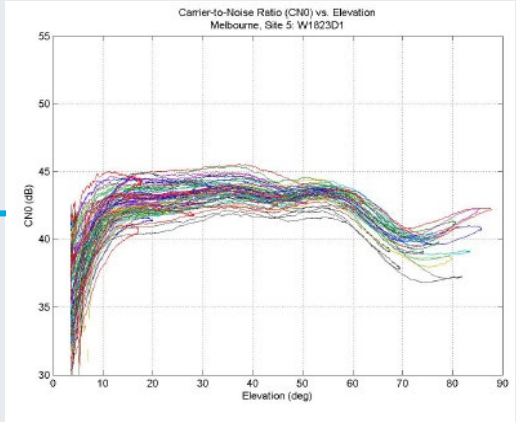
4 *"All masts & towers shall be designed in accordance with Australian Standard – Design of steel lattice towers and masts (AS 3995-1994)."*

DESIGN AND IMPLEMENTATION – SITE ASSESSMENT

SITE SELECTION PROCESS

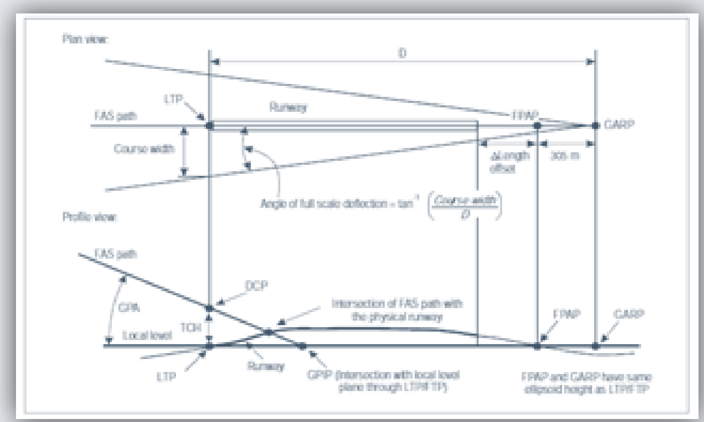
- Identify preliminary sites based on Honeywell Siting Process
    - Soil stability, VDB siting, RR siting, Protection Surfaces and future infrastructure
- Set up a GPS antenna/receiver to evaluate GPS environment
    - GPS Multipath
    - Radio Frequency Interference
- VHF coverage modelling using available software tools

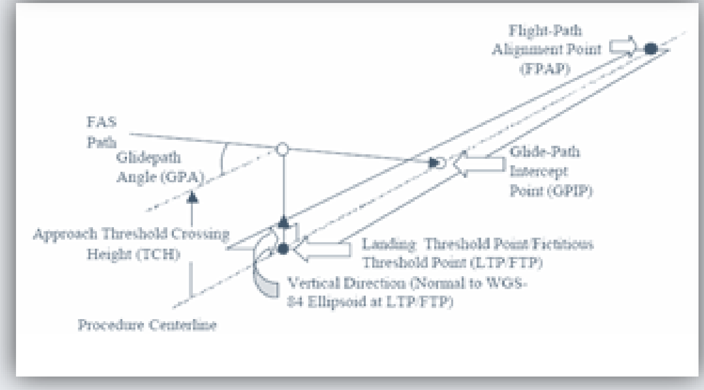


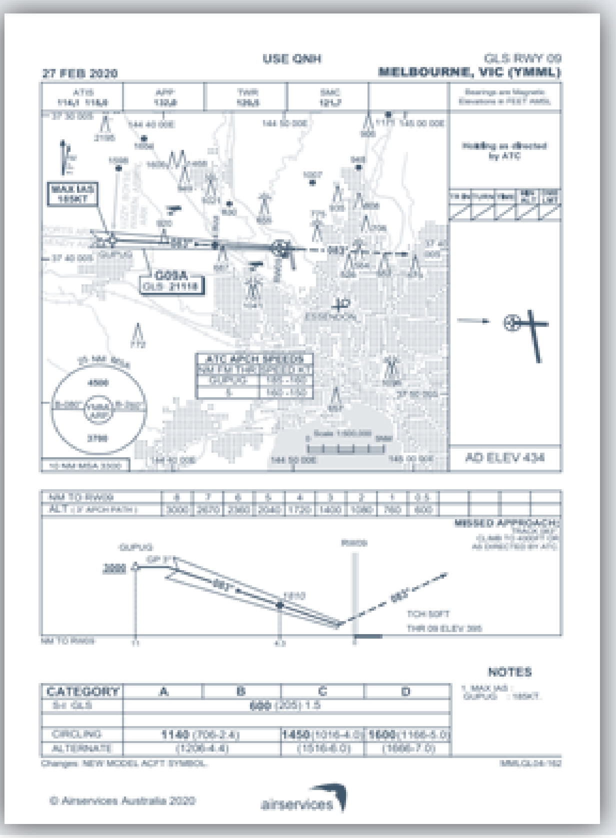


DESIGN AND IMPLEMENTATION – PROCEDURES DESIGN

FAS DATA AND APPROACH PLATE DEVELOPED BY PROCEDURES DESIGNER. PROVIDED TO ENGINEERING TO CONVERT INTO A BINARY FILE FOR LOADING ONTO THE GBAS.







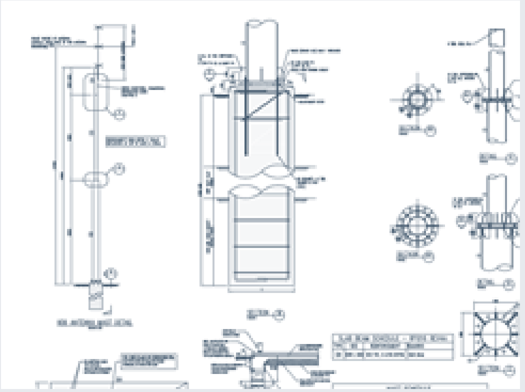
Aerodrome Location	Frequency (MHz)	Runway	Channel	IDENT
YMML	115.4	09	21118	G09A

Item	Units	Range of Values	Resolution	Value
Operation Type	-	0 = Straight in Approach 1 to 15 = Spare	1	0
SBAS Service Provider	-	0 to 13 = Not used in Australia 14 = FAS Data Block is to be used with GBAS only 15 = FAS Data Block can be used with any SBAS service provider	1	14
Airport ID	-	AAAA to ZZZZ	-	YMML
Runway Number	-	1 to 36	1	9
Runway Letter	-	0 = no letter 1 = R (right) 2 = C (centre) 3 = L (left)	1	0
Approach Performance Designator	-	0 = GAST A or B 1 = GAST C (Category I) 2 = GAST C and GAST D 3 = GAST C, GAST D and an additional approach service type to be defined in the future 4 = GAST C, GAST D and two additional approach service types to be defined in the future 5 to 7 = Spare	1	1
Route Indicator	-	A to Z	-	W
Reference Path Data Selector (RPDS)	-	0 to 48	1	2
Reference Path Identifier	-	3 or 4 letter alphanumeric characters (IDENT)	-	G09A
LTP/FTP Latitude	degrees	± 90.0°	0.0005 arcsec	-37°39'58.7055"
LTP/FTP Longitude	degrees	± 180.0°	0.0005 arcsec	144°49'20.1030"
LTP/FTP Height	metres	-512.0 to 6041.5 m	0.1 m	125.8 m
Δ FPAP Latitude	degrees	± 1.0°	0.0005 arcsec	-0°00'05.4185"
Δ FPAP Longitude	degrees	± 1.0°	0.0005 arcsec	0°01'33.0230"
Approach Threshold Crossing Height (TCH)	metres or feet	0 to 3276.7 feet or 0 to 1638.35 m	0.1 feet or 0.05 m	50.0 ft
Approach TCH Units Selector	-	0 = Feet 1 = Metres	-	0
Glide Path Angle (GPA)	degrees	0 to 90.0°	0.01°	3.00°
Course Width	metres	80 to 143.75 m	0.25 m	105.00 m
Δ Length Offset	metres	0 to 2032 m	8 m	0 m
FASVAL	metres	0 to 25.4 m	0.1 m	10.0 m
FASLAL	metres	0 to 50.8 m	0.2 m	40.0 m

DESIGN AND IMPLEMENTATION – INSTALLATION & INTEGRATION

Site Design

1



Civil Works

2

Shelter & Tower Installation

3

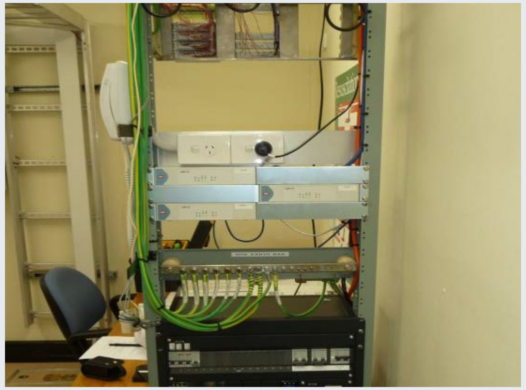
4

RSMU Installation

5

VDB Installation

6

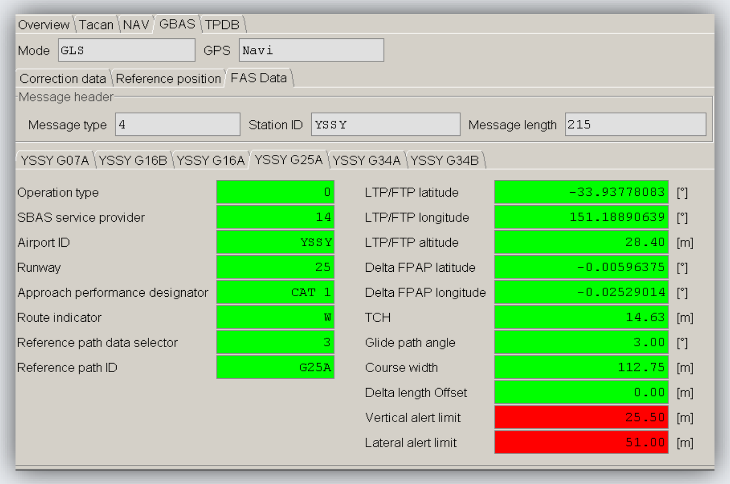


Integration into ATM Systems

DESIGN AND IMPLEMENTATION - VERIFICATION ACTIVITIES

FACTORY ACCEPTANCE TESTING

Verify Honeywell SLS-4000 GBAS is operating correctly and identification of any issues before installation.

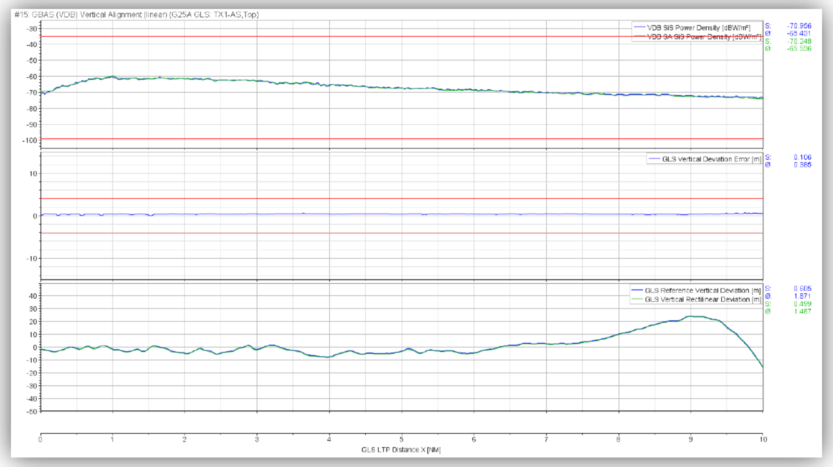


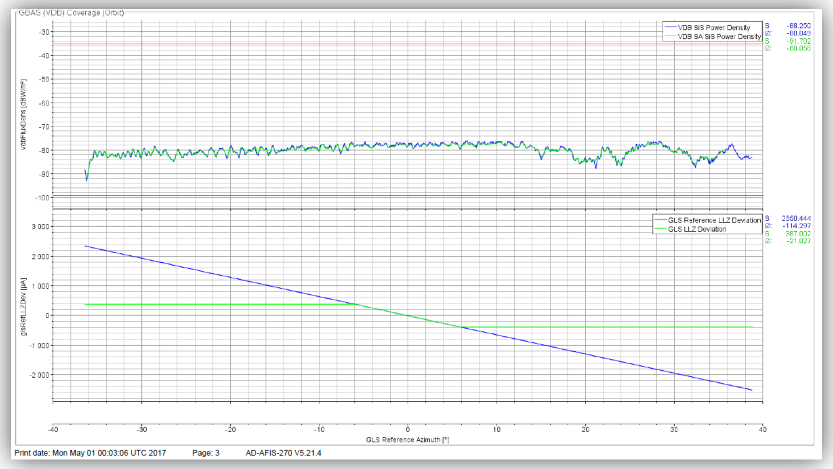
SITE ACCEPTANCE TESTING

Stability testing, end to end functionality testing of the installed system, configuration audits and initial performance analysis.

FLIGHT INSPECTION

Verify VHF Data Broadcast (VDB) coverage, validate Final Approach Segment data and conduct a position domain functional check.

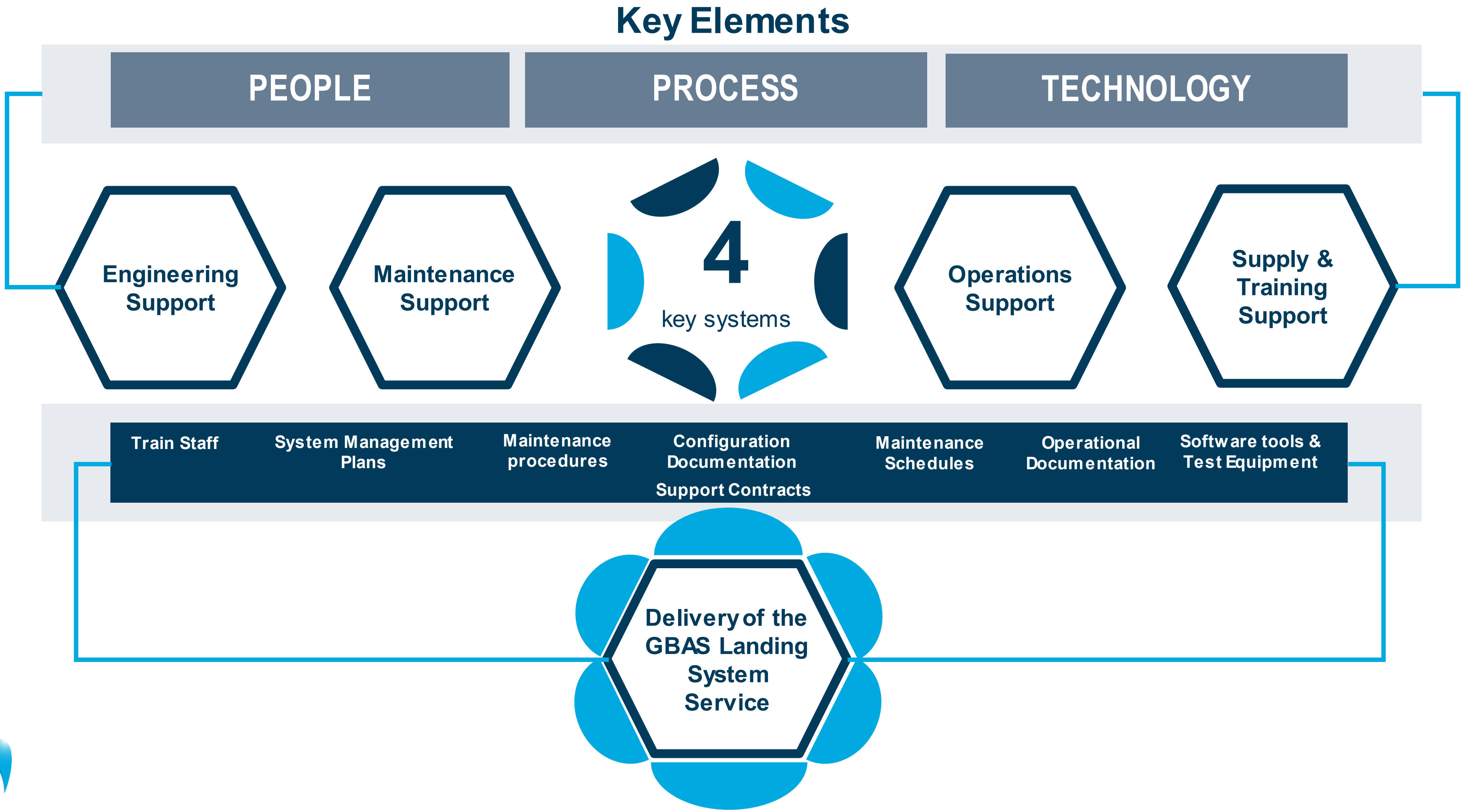




airservices

SUPPORT SYSTEMS

Airservices were required to establish a number of Support Systems in order to effectively operate and maintain the GBAS. This was a critical element to demonstrate to the regulator that the appropriate people, process and technology were in place to support Service delivery.

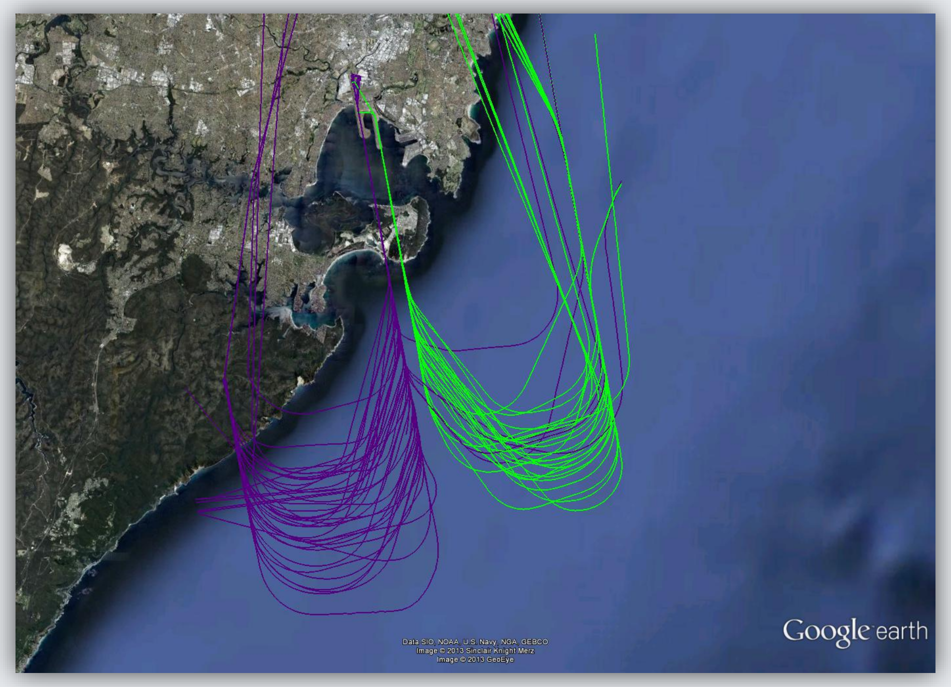


OPERATIONAL TESTING

At this stage there was no change to Airservices Aeronautical and Radionavigation Service Provider Certificate. Operational Evaluation was conducted under test transmissions.

TESTING IN A REAL WORLD ENVIRONMENT

- Subsequent to Engineering readiness, Safety Case (Version 1) submitted and accepted by CASA
- Objectives
  - Validate GBAS is meeting designed System Performance parameters
  - Validate that the service is operating as intended through aircraft using the GLS service
- Open to “CASA Authorised Operators” only. Visual conditions only (Decision Height: 2100 feet and Visibility: 5000 m)
- Temporary Local Instruction in place for ATC



Pilot Feedback:

“Very good intercept and approach was flawless”

CAT I OPERATIONS

Airservices Aeronautical and Radionavigation Service Provider Certificate was updated to include GBAS.

OPERATIONALISING THE CHANGE

- Hazards reviewed and updated to reflect CAT-I operations
- ATC instructions integrated into procedures and Aeronautical Information Publication documents update
- All evidence collated during the Operational Evaluation consolidated into Version 2 of the Safety Case and accepted by CASA
- Future GBAS deployments managed as any other Navigation Aid deployment

CASR-171 Service Classifications (Chapter 2 MOS Part 171)	Coverage	ICAO Defined Services	Airways Systems	Support Services (External)
AERONAUTICAL RADIO NAVIGATION	National	Aeronautical Radio Navigation	• Distance Measuring Equipment • Instrument Landing System – Localiser, Glide Path and Marker • Non Directional Beacon • Very High Frequency Omni-Range • Ground Based Augmentation System **Common Systems** • Communications systems - Microwave radio links - Satellite ground stations - Terrestrial cabling - Multiplexers - Data networking systems • Voice Communication and Control System • Audio and Control Systems • ATC Consoles	• Public Telecommunication Networks - Telstra - Optus • Copper and Fibre cables(Airport Owner)

List of Airways Systems updated to include GBAS

CASR-171 Certification

Australian Government
Civil Aviation Safety Authority

Instrument Number: CASA.171.0013 Issue No: 16

I, Andrew Sparrow, Branch Manager, Air Navigation, Airspace & Aerodromes, National Operations & Standards, a delegate of CASA, make this instrument under regulation 171.027 of the *Civil Aviation Safety Regulations 1998*.

Andrew Sparrow
Branch Manager
Air Navigation, Airspace & Aerodromes
National Operations & Standards

11 December 2020

Approval – Aeronautical Telecommunication and Radionavigation Service Provider

1 Repeal

Instrument Number CASA.171.0013 Issue No: 15 is repealed.

2 Application

This instrument applies to AIRSERVICES AUSTRALIA (the **operator**), ARN 202210, whose principal place of business is 25 Constitution Ave, CANBERRA, ACT 2601.

3 Approval

The operator is approved to provide the aeronautical telecommunication and radionavigation service described in Schedule 1 in accordance with its Operations Manual subject to any conditions and limitations expressed therein.

4 Conditions

It is a condition of this approval that the holder may only conduct the kinds of telecommunication or radionavigation services in the areas, and during the times, if any, specified in Schedule 1.

5 Repeal of this instrument

This instrument is repealed at the end of 31 May 2023.

Part 171 Approval: CASA.171.0013 *Revision:* 16 *Page 1 of 9*

airservices

THANK YOU

Ritesh Kapoor

Senior Engineering Specialist

ritesh.Kapoor@airservicesaustralia.com

airservicesaustralia.com

GPO Box 367 Canberra ACT 2601
Airservices, Alan Woods Building, 25 Constitution Avenue, Canberra ACT 2600, Australia
T: 61 2 6268 4111 F: 61 2 6268 5693 ABN: 59 698 720 886

Fourth meeting of GBAS-SBAS Implementation Task Force (GBAS-SBAS ITF/4)
Video Teleconference
11-12 May 2022

airservices

GBAS - ATC PERSPECTIVE

Ritesh Kapoor
ritesh.kapoor@airservicesaustralia.com

BENEFITS OF GBAS - ATC

01 Expect no equivalent ILS Critical or Sensitive areas to protect allowing greater operational flexibility.

02 No loss of service during periodic flight calibration activities allowing the facility to remain in service.

03 Seamless transition from the ILS to GLS with minimal changes to existing practices.

GBAS CONCEPT OF OPERATIONS

A dedicated GBAS Concept of Operations was developed to articulate how the GBAS would be used in the current Air Traffic Management environment. The Concept of Operations essentially involved replicating existing ILS practices.

KEY CONCEPTS

Operational Use

The introduction of GLS approaches should result in minimal changes to existing pilot and ATC interactions and should be fully integrated with existing airport operations (e.g. Parallel runway operations).

Service Levels

The GBAS should conform with ICAO Annex 10, Volume 1, Standards and Recommended Practices and replicate existing CAT-I ILS service levels.

Procedures Design

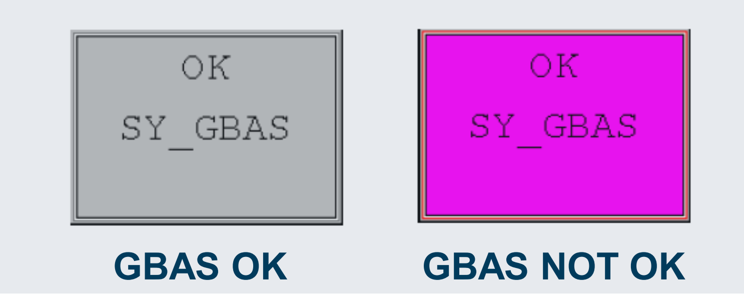
GLS procedures designed to be ILS and/or RNAV(GNSS) look-alike to fit in with existing ATC procedures.

ATC Procedures

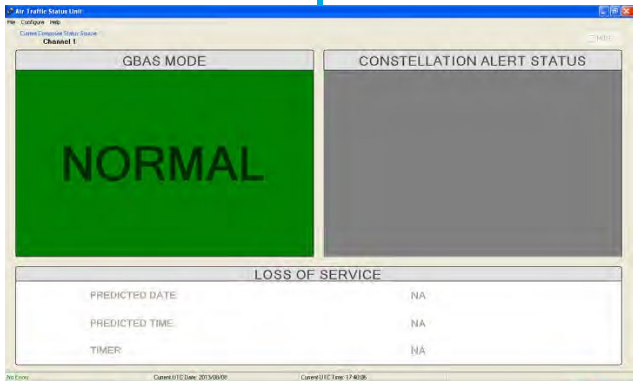
Introduction of GBAS should require minimal changes to ATC procedures and phraseology. GBAS status indications will be provided to Tower and Terminal Control executive positions.

SUMMARY OF CHANGES - ATC

AREA	SCOPE OF CHANGE
Sectorisation/Airspace	No change
Traffic Processing	No change
Phraseologies	Additional phraseology (e.g. “Cleared GLS”)
Separation	No change
Information provided to pilots	Additional GBAS information on ATIS (e.g. “Expect GLS”)
Documents	Local instructions and training documentation updated
Workstation operation	New GBAS monitor on Controllers screen
Equipment	New laptop used for advice of Constellation Alerts
HMI	Indication of aircraft approach in label data field *(no longer used)*
Abnormal/Emergency Operations	No change
Handover/takeover	Inclusion of GBAS information in Handover/Takeover
Degraded Modes	No change



GBAS MONITOR ON CONTROLLERS SCREEN



GBAS LAPTOP USED FOR CONSTELLATION ALERTS

airservices

GBAS TRAINING - ATC

ATC TRAINING NEEDS ANALYSIS

- An ATC Training Needs Analysis (TNA) was completed in accordance with existing Airservices practices. This included:
  - GAP analysis – Impact of changes and determination of training required
  - GAP learning – Analysis of knowledge and skills required
  - Training resources, methods and delivery requirements
- Briefings provided to ATC on the GBAS by the project team
- Local instructions updated and a group circular developed. Briefings conducting internally within ATC.
- ATC provided with a briefing package on GPS satellite constellation alerting practices
- Practical skills consolidated through ongoing On The Job training for ATC

Melbourne Ground Based Augmentation System installation

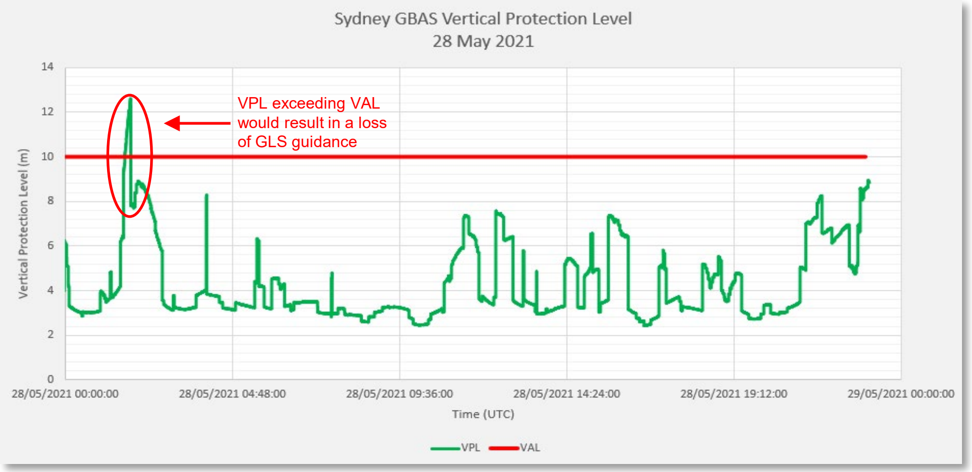
Table of contents

airservices

GBAS CONSTELLATION ALERTING - ATC

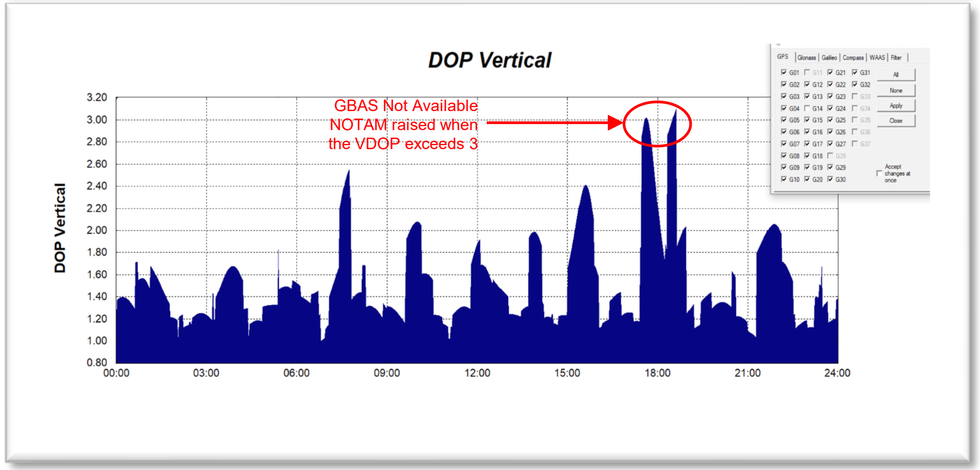
CONSTELLATION ALERTING PRACTICES

- Post implementation a limited number of aircraft reported a loss of vertical deviation indications whilst performing a GLS approach
- In response to these reports the GBAS was removed from service
- Loss of GLS guidance was due to the Vertical Protection Level (VPL) exceeding the Vertical Alert Limit (VAL)
- Attributed to the prevailing GPS satellite constellation being unable to support CAT-I precision approaches
- Airservices implemented a separate Constellation Alerting process
- GLS is not available during periods the GPS satellite constellation is predicted to be unable to support CAT-I precision approaches



EXAMPLE NOTAM

```
GROUND BASED AUGMENTATION SYSTEM (GBAS) NOT AVBL DUE CONSTELLATION
AVAILABILITY
FROM 05 111748 TO 05 171742
   1705111748 TO 1705111806
   1705121744 TO 1705121802
   1705131740 TO 1705131758
   1705141736 TO 1705141754
   1705151732 TO 1705151750
   1705161728 TO 1705161746
   1705171724 TO 1705171742
```



airservices

KEY LESSONS LEARNT

01 Initial Maximum Use Distance (Dmax) limitation of 23 NM presented challenges for ATC (especially during parallel runway operations where a course check is performed outside of 23 NM). Extended to 50 NM in 2020 reducing both pilot and ATC workload.

02 Loss of GLS course guidance observed in a limited number of aircraft resulting in removal of GBAS from service. Constellation Alerting practices introduced to preserve Continuity of Service. Briefing industry and internal stakeholders on differences to ILS is key.

03 GBAS approaches are the preferred approach method into both Sydney and Melbourne based on industry feedback.

THANK YOU

Ritesh Kapoor

Senior Engineering Specialist

ritesh.Kapoor@airservicesaustralia.com

airservices