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Aircraft Design & Operation
Briefing Leaflet

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Ground Based Augmentation System (GBAS) and GBAS Landing System (GLS)

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INTRODUCTION

GBAS (Ground Based Augmentation System) and **GLS** (GBAS Landing System) is a GNSS (GPS) based approach and monitoring system that utilises a local airport facility to increase the accuracy and integrity of the position of an aircraft both vertically and laterally to support a Precision Approach.

This system is in operation or in trial at many airports globally including Newark, Charleston, Houston and Moses Lake in the United States, Sydney in Australia, Bremen and Frankfurt in Germany, and Malaga in Spain.

The FAA is currently working on design approval for GLS for CAT III operations, and operations can be expected to commence when aircraft are certified for GLS CAT-III.

The purpose of this Briefing Leaflet is not to give too much in-depth technical information, but to enable IFALPA members an overview of the GLS and GBAS, how it works, the systems requirements on the ground and in the aircraft, and a pilot's perspective on the system.

GBAS BACKGROUND

GNSS has become commonplace in aviation over the past 10-15 years. Most crewmembers are familiar with GNSS operations for departure, en-route, and approach and landing phases.

There have been, however, inherent limitations on GNSS operations that stem from the possible lack of availability of satellites to ensure the accuracy of the aircraft's location and errors in the aircraft's apparent position, and uncertainty in signal delay as it passes through the ionosphere on its journey from the satellite to the aircraft receiver.

This has improved over the years with more satellites becoming available, tighter system control and system improvements, resulting in a consequential steady reduction of Required Navigation Performance (RNP) from 10 through to 4 and 2 for en-route phases and even down to 0.1 for RNP-AR approaches.

The limitations on this system are well known, including ensuring RAIM is available and receivers and satellites are working properly and ionospheric effects. The primary precision approach facility for more than 60 years has been the Instrument Landing System (ILS). This is a tried and tested facility that has enabled a high level of accuracy in lateral and vertical guidance to an aircraft in landing phase, and this has resulted in extremely high levels of safety over the years.

The ILS, however, still has some drawbacks. The main issues revolve around equipment availability and positioning. The ILS consists of 2 main components: the Glideslope for vertical guidance and the Localiser for lateral guidance. If either of these becomes unavailable for whatever reason, an approaching aircraft has to resort to a Non-Precision Approach, which is well known to increase pilot workload, decrease accuracy, and increases the probability of CFIT incidents.

There is also the problem of environmental issues affecting the ILS. It is not uncommon to see an offset Localiser due to local terrain effects or space availability on the airfield at the end of the runway for the antenna. The Glideslope has problems with possible false lobe capture, as well as having to ensure that the critical area is protected during approaches to ensure the Glideslope is accurate and readable by an approaching aircraft.

Traditional GNSS approaches (RNAV and RNP-AR) have become commonplace and most crews are very familiar with the GNSS system. However, again, it does not yet have the accuracy or integrity of an ILS system, which is particularly important close to the ground, and it is still subject to errors of varying degrees and has inherent limitations. GLS takes the GNSS system to the next level by providing information, which is used with GPS signals, to enable the aircraft to determine its location both horizontally and vertically with sufficient accuracy and integrity to support Precision Approach minima.

GBAS SYSTEM

The GLS consists of the constellation of GPS satellites (space segment) as well as a GBAS, comprising a number of antennae (usually 4), a central processing unit, VHF data broadcast (VDB) transmitter with omni-directional antenna (ground segment), which are all located on, or very near to, the airport. There is also the requirement for aircraft receivers and equipment (airborne segment). The GBAS antennae are located at super-highly accurate surveyed positions.

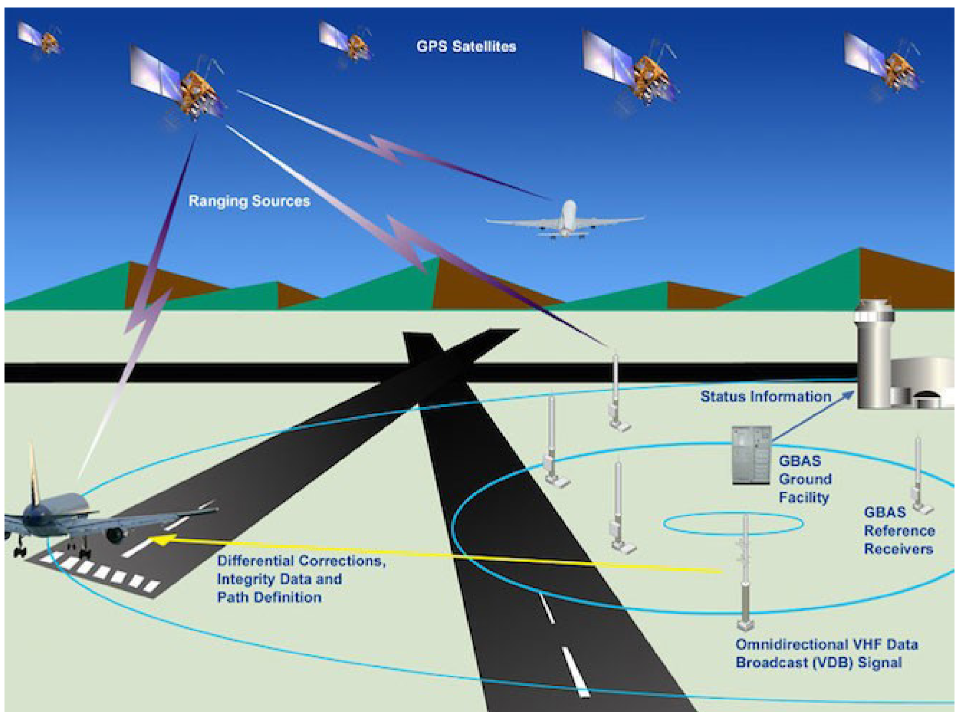

Image: FAA website

Honeywell, the system designers, knows the approach itself, as a "SmartPath". The GLS approach path is designed the same manner as an ILS; a runway aligned azimuth approach with an optimal 3-degree vertical approach path with a set "service volume". This service volume distance (Dmax) is the maximum distance to which the corrections may be used with the required integrity guarantee.

The receiver antennae take the GPS signals being transmitted from the satellite, and the GBAS computes the range to the satellite and compares it to the known exact range; the difference is the range correction which is broadcast to aircraft via the VDB transmitter. Integrity information is also transmitted to the aircraft.

The approach path definition is the third piece of data broadcast to aircraft. Each approach procedure has a separate identifying number (e.g. 21146 for 16R in Sydney), which is tuned in the aircraft, similar to an ILS or VOR frequency, via a multi-mode receiver (MMR). Embedded in the Approach Procedure identifying number is the VHF frequency, data-link time slot and approach procedure.

The signal is sent and received via existing VOR band allocation. The GBAS has its own VDB receivers, which listens to each transmission, and the received data is crosschecked for errors and data corruption.

The aircraft automatically, upon tuning and receiving the GLS signal, carries out an ident. The pilot is not normally required to make an aural ident (company procedures may dictate otherwise), but they are required to confirm that the Approach Procedure ID for that runway is shown on the PFD or where the ILS ID is usually found. In the case of GLS 16R YSSY approach, this would be displayed as G16A. If the pilot chooses to check the aural ident, the morse code would be “G 1 6 A”. This would be done the same as you would ident an ILS. The aural ident is generated in the MMR based on the procedure definition unlinked from the GBAS. This gives backward compatibility and similarity to ILS for training and familiarity purposes.

The aircraft then flies, and presents the lateral and vertical deviation from the desired approach path to the pilot, exactly like an ILS. The position error on a GBAS approach is generally no greater than 1m both vertically and horizontally.

For the airport operators there is also a major cost benefit for installing a GBAS. For example, the SmartPath GBAS at Sydney is able to broadcast 26 separate approach procedures in the system. There is a GLS approach for each of the runway ends at Sydney, so the one GBAS system allows 6 approaches, rather than requiring 6 Localisers and 6 Glideslopes.

This level of flexibility extends further. If there were semi-permanent works on one runway that required a displaced threshold, the GBAS software can be set up for a second approach onto that runway at the new displaced threshold. This raises the level of safety by providing an “on-the-spot” precision approach, negating the requirement for a vertical offset NPA with the associated visual illusions, regardless of available runway length.

A multi-mode receiver panel on a B737-800

The system is almost totally duplicated for redundancy. There are 2 pairs of data processors, each processor of a pair performs the algorithm calculations and they mutually crosscheck each other for errors before sending the data to the aircraft. There are 2 VDB transmitters, and 2 VDB receivers for transmission error crosschecking, and 2 power supplies and 2 backup batteries. The system can operate normally with 3 of the 4 antennae operational, in the event of the failure of one antenna. If the system fails or detects corruption, the whole system will cease transmission of correction to prevent any erroneous information sets being sent to aircraft. The system will generally <u>not</u> take out vertical path and leave horizontal guidance like a Glideslope failure on an ILS.

SmartPath is currently certified and approved for CAT-I operations. The system supports autoland if the aircraft is capable (approval to conduct autoland operations is a separate issue). Currently, there is flight-testing underway in the USA to validate enhancement of GLS to CAT III operations. However, it’s worth remembering, the landing system is just one part of a CAT II/III system, with the normal requirements for Low Vis Operations such as lighting, RVR, surface radar and aircraft certification still remaining.

PILOT PERSPECTIVE

From an operating pilot's perspective, there is very little difference to a conventional ILS approach. An aircraft will fly a STAR or receive radar vectors, the same as what would happen for any other approach. The pilots will select the GLS approach in the FMS system. They will then tune the multi-mode receiver to the appropriate channel number rather than an ILS frequency.

Once the aircraft receives the SmartPath signals (inside Dmax), all displays will be identical to a conventional ILS approach. The pilots will receive a "distance to go" readout (the same as a conventional DME), and a lateral deviation and vertical deviation display (the same as a conventional LOC/GS).

The biggest issue from feedback from pilots has been "how do you know you are within range of the GBAS station?" This is worth bearing in mind for the GLS approach, particularly where the aircraft may be aligned with the runway from a significant distance under vectors or on the STAR.

FURTHER INFORMATION

GBAS takes away many, if not most, of the system limitations of an ILS. There is no interference from aircraft on taxiways; hence there is no "Critical Protected Area". There is no Localiser scalloping when an aircraft passes in front of the antenna on departure or when taxiing or under tow, and, as mentioned previously, it allows a Precision Approach and autoland, even when runway has a reduced length.

There is still some of the space weather issues associated with any space-based navigation system, however, given the updating from the GBAS itself, the errors are greatly reduced.

There have been issues of bandwidth interference at one airport in the US, but no ongoing issues have been documented.

There is no ICAO documentation as yet regarding simultaneous parallel approaches for GBAS, however some airports have already introduced this procedure following risk modelling.

A RNP-AR Approach Procedure and a GLS Approach Procedure can be designed to allow transition from the RNP-AR approach to GLS (short) final approach. Thus, the benefit of RNP-AR curved path and the lower minima of the GLS could be realised at some time in the future.

However, the limitation is that while RNP-AR is a based on barometric altimeter, GBAS is geometric based. To blend the 2 types of approaches, the RNP-AR procedure would need to deliver the aircraft a little below the GLS vertical path to ensure intercept from below for all conceivable barometric settings. This would cause a small vertical discontinuity with the change in guidance from RNP-AR to GLS.

There is also work underway to allow GBAS to be utilised within the terminal area in the future. These expansions of the technology may be some years away however.

There is no doubt that GBAS and GLS is the next generation of precision approach system with current CAT-I availability and certification for CAT-III in the next few years. However, it important to remember that no system, no matter how good it is, is no replacement for good technical knowledge, flying skills, airmanship and strict adherence to SOP's.