REALIZING THE POTENTIAL FOR MORE CAPACITY

The GBAS ground station and the VHF data broadcast antennae at Frankfurt Airport and above a departing aircraft B747-8 – the system can now be used for CAT II approaches

An upgraded GBAS system for Category II approaches at Frankfurt Airport promises more capacity during low visibility operations

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DFS, the German air navigation service provider, introduced the ground-based augmentation system (GBAS) for satellite-based precision landings under the low visibility conditions of meteorological category II in July 2022. This corresponds to a cloud base of 100ft (30m) and a minimum runway visibility range of 1,000ft (300m). This system can support Category I and II operations. It is the first system in the world capable of providing public GBAS Category II approach services.

GBAS CAT II at Frankfurt Airport

The German national supervisory authority (BAF) certified the system in March 2022. From 14 July 2022 on, DFS has published GLS (GBAS Landing System) CAT (Category) II approach procedures with a 3˚ and 3.2˚ glideslope for operations at Frankfurt Airport. Flight LH 273 from Milan Linate performed the first landing using the procedure on that same day. DFS approach controllers guided the Airbus A319 to a final approach point at 25 nautical miles (46km) and 8,000ft. From there, the aircraft performed a continuous descent with idle thrust followed by an automatic landing.

The GBAS CAT II service at Frankfurt Airport permits an expansion to 35 nautical miles (65km) and 10,000ft from the reference point on the ground. This allows air traffic controllers to clear arrivals at higher altitudes and longer distances than before – a major benefit supporting environmentally friendly continuous decent operations.

DFS has been operating precision landing systems under good weather conditions (CAT I) at Bremen Airport since 2012 and at Frankfurt Airport since 2014. Both of the installations are certified to the ICAO GBAS Approach Service Type (GAST) C standard. In CAT I, the pilot is required to see the runway approach lights at 200ft above ground level to continue the precision approach.

GBAS benefits

Satellite-based landing systems using ground-based augmentation are currently being developed and deployed worldwide. Airlines, ANSPs and manufacturers have been collaborating on a worldwide scale. In addition, the SESAR program is working towards replacing instrument landing systems (ILS) with GBAS, among others.

One of GBAS's major benefits lies in its cost-efficiency. Only one ground station is needed to service multiple approaches to all

Above: GBAS ground station and VHF data broadcast antennae at Frankfurt Airport

Below: The GBAS Landing System in an A319 cockpit: left is the navigation display, and right the primary flight display; GLS indicates that the aircraft does not orientate itself to the ILS, but to the GBAS signals

runway ends at an airport. From an operational perspective, GBAS has the potential to increase runway capacity during low visibility operations by enabling reduced spacing on final approach. Increased glideslopes up to 3.2˚ and continuous descent operations allow for benefits also regarding noise, fuel burn and greenhouse gas emissions.

Global efforts to expand GBAS

As part of the SESAR project Demonstration of Runway Enhanced Approaches Made with Satellite Navigation (DREAMS) DFS, Lufthansa and Airbus have worked on the expansion of satellite-based precision landings in poor and low visibility weather conditions. The project has demonstrated that an upgrade of the GBAS ground station at Frankfurt Airport can support GLS approaches down to CAT II.

For the CAT II approach, an aircraft that is already equipped and enabled for GBAS approaches under CAT I does not need technical changes: These aircraft can perform GLS CAT II approaches. Only approval / certification for this kind of operation from their regulatory authorities is required. Currently, the Boeing types 737, 787, 747-8 and in future 777X, as well as the Airbus A320 family are among those approved by the manufacturers. Generally, most modern airliners are GLS equipped, but the GLS capability needs to be enabled.

At Frankfurt Airport as of July 2022, the equipage rate for aircraft with enabled GLS capability is currently about 10%. This rate could be increased if more airlines would enable the service.

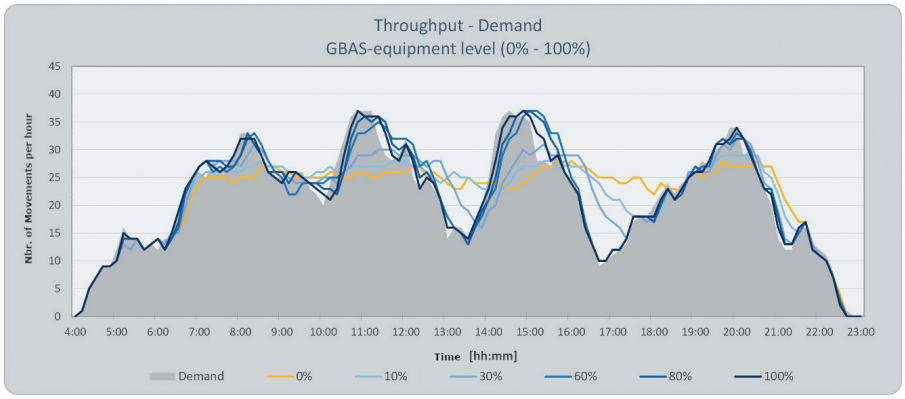
Technical upgrades

A major challenge for differential GPS systems like GBAS is their sensitivity to spatial de-correlation due to variation in ionosphere delay between the aircraft and the ground. Therefore, DFS has upgraded the Honeywell SLS-4000 GBAS station located at Frankfurt Airport with an SBAS receiver that provides additional information on the status of the ionosphere. In contrast to a single GBAS ground system, a satellite-based augmentation system (SBAS) has a network of dual-frequency ground receivers, which is capable of directly measuring the ionospheric errors in a larger region. The integrated SBAS receiver, which makes use of the European navigational service EGNOS, improves the observability of the ionosphere for GBAS and further limits uncorrected errors.

In case of acceptable ionosphere disturbance, the ground station switches to Service Level B, which is required to support precision approaches to the CAT II minimum. Whenever the integrated SBAS receiver or the EGNOS service is not available or there is severe ionosphere activity – which is very unlikely in mid-Europe regions – the station reverts to Service Level A, which is a downgrade to CAT I service only. On the ground, CAT II operations require specific continuity, instead of the average continuity for CAT I operations, as well as data link coverage on all supported runways.

Maintaining approach capacity

From an ANSP perspective, one of the advantages of GBAS can potentially be an increase of runway capacity during low visibility operations (LVO). The main parameter limiting the landing capacity of a runway system during LVO is the runway



occupancy time. This is the time the aircraft needs on the runway to decelerate and to vacate the runway up to a specific distance.

For the ILS, protection zones on the ground – known as critical and sensitive areas – must be considered to avoid a signal deformation for the succeeding aircraft when an aircraft, which has just landed, is inside these areas. Therefore, greater separation on final approach must be applied which reduces runway capacity.

GBAS does not require such protection zones as it uses a digital data link from the ground station to the aircraft that cannot be deformed. Thus, air traffic controllers can apply smaller separation for GBAS equipped aircraft, limited by required wake turbulence separation only. This means arrival capacity can be maintained at a high level.

Fast-time simulations

To evaluate the differences between GBAS and ILS and the potential benefits of GBAS during low visibility operations, DFS has conducted several fast-time simulations. In a prior simulation project, the consequences of operations of exclusively using GBAS CAT II were compared with pure ILS CAT II operations. Recently the effects of traffic with mixed GBAS and ILS equipped aircraft have been analysed. This delivered a more nuanced picture.

The results indicate that an increase in capacity can be achieved with GBAS CAT II approach procedures. According to the simulations, GBAS CAT II has the potential for a significant gain of throughput and less delay compared to ILS CAT II operations. The simulations show that this applies already if a small proportion of aircraft are equipped with GBAS, for example 10 or 30%.

With an equipment level of 60% the throughput can be significantly increased. Traffic can be handled with a significantly reduced delay compared to the other scenarios with a lower GBAS equipment level.

The increase of GBAS-equipped aircraft to 80 or 100% does not lead to a further increase in runway throughput with reference to the traffic sample in the simulations. Only traffic peaks can be handled almost without delay. Overall, delay decreases, though at a comparatively low level.

In summary, the step from a GBAS equipment level of 30 to 60% has a very positive effect on throughput, whereas delay can significantly be reduced at lower equipment levels of 10 to 30%.

The reasons for the capacity increase are the missing protection zones for GBAS operations and the landing clearance line concept, which allows the aircraft to be clear of the runway at an earlier point in time. However, it must be considered that the capacity gains also depend on the number of heavy aircraft, because most of the restrictions when operating with ILS are caused by aircraft of the wake turbulence category "heavy".

When interpreting the simulation results, it should be kept in mind that all values are based on one simulated scenario with predefined assumptions. These assumptions include consideration of arrival traffic on runway 25R at Frankfurt Airport only, fixed runway exit usage for medium and heavy wake turbulence category aircraft and no consideration of ground movement processes. Nevertheless, the results of the simulations demonstrate that greater runway capacity is achievable under low visibility conditions when using GBAS, instead of with ILS.

Above: Throughput and demand due to GBAS equipment level in simulation scenarios

Below: Average arrival delay due to GBAS-equipment level in simulation scenarios

Can GBAS replace ILS?

To be able to use GBAS as a fully-fledged replacement for the current instrument landing system, it will be necessary to certify GBAS ground facilities for CAT III operations in accordance with ICAO standard GAST D. This standard has been in force since the end of 2020. Currently, the first prototypes of such ground facilities exist, at Frankfurt Airport for example. The certification is currently stalled due to a lack of grant funding. Boeing has announced the availability of GAST D on its 777X aircraft type. Other aircraft manufacturers are still cautious because of the lack of ground infrastructure.

Through joint implementation projects, the European GBAS Alliance aims to bridge this gap between on-board and ground systems. This Alliance comprises representatives from IATA, airlines, ANSPs and airports, among others, and considers European funding crucial to advancing ground system certification and the equipping of aircraft. DFS and other European ANSPs have signalled that they will take further steps in a timely manner as soon as the availability of certified facilities is ensured. ❖

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