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International Civil Aviation Organization
South American Regional Office
Sixth Meeting of Air Navigation and Flight Safety Directors of the SAM Region (ANFS/6)
(Lima, Peru, 24 to 26 June 2019)

Agenda Item 1: Follow up to the implementation of national air navigation plans

DEVELOPMENT OF A GBAS SYSTEM

(Presented by Argentina)

SUMMARY

The National civil aviation administration (ANAC) of Argentina, together with INVAP S.E., a technology company, has developed a ground-based augmentation system (GBAS) precision approach and landing system, which has been implemented at the international airport of San Carlos de Bariloche - SAZS. It receives information from the visible satellites of the GPS constellation, makes corrections to pseudo-distance, monitors integrity, and generates and transmits type 1, 2, and 4 messages to support positioning and Cat I precision approaches, as specified in ICAO Annex 10, Aeronautical telecommunications, Vol. 1.

ICAO strategic objectives:	The issue under reference tends to meet the strategic objectives established by ICAO for the period 2005-2010, in its *CONSOLIDATED VISION AND MISSION STATEMENT* adopted by the Council on 17 December 2004, namely: A) Safety – Enhance global civil aviation safety; B) Security – Enhance global civil aviation security; C) Environmental protection - Minimise the adverse effect of global civil aviation on the environment; D) Efficiency – Enhance the efficiency of aviation operations; and E) Continuity – Maintain the continuity of aviation operations. Likewise, the topic falls within the strategic objectives of the *Global air navigation plan (GANP) 2013 – 2028.*
References:	- Annex 10, Aeronautical Telecommunications, Vol. I, Radio Navigation Aids - Annex 14, Aerodromes, Vol. I, Aerodrome Design and Operations - ED-114A, MOPS for GBAS to Support Category I. - Order 6884.1, FAA, Siting Criteria for GBAS.

1. Background

1.1 INVAP (*Investigación Aplicada) Sociedad del Estado*, is an high-technology Argentinian company engaged in the design, integration and construction of factories, equipment and devices in high-complexity areas such as nuclear energy, spatial technology, industrial technology and medical and scientific equipment. It is considered as one of the best scientific institutions of the world and the most prestigious in Latin America.

1.2 Since its creation, the company has gained prestige in the design and provision of systems for nuclear reactors and the provision of nuclear reactors for research and testing. Since the late 1990's, the company ventured into the airspace sector, especially with the design, construction and operation of satellites and radars.

1.3 The incursion of INVAP into the radar field started in 2004 when SINVICA (*Sistema Nacional de Vigilancia y Control Aeroespacial*), the national aerospace oversight and control system, was created in Argentina, with the purpose of providing a radar system to perform airspace defence tasks and to provide an efficient air traffic service. As a result, a contract was signed between the national government and INVAP for the design, manufacturing and implementation of secondary radars, 22 of which already oversee the Argentinian continental airspace. This continued in 2007 with the development and manufacturing of primary radars, and then with radars for meteorological use.

1.4 The owner is the province of Río Negro, in whose board sits the national government through the National Atomic Energy Commission (*Comisión Nacional de Energía Atómica* - CNEA).

1.5 INVAP is certified under ISO 9001:2008 (Quality Management) and ISO 14001:2004 (Environmental Management).

1.6 INVAP has a staff of more than 1000 (85% professionals and specialists), and more than 700 indirect employees. It is the only Latin American company recognised by NASA as capable of developing complete satellite systems, from design and construction to operation, excluding launching.

1.7 In view of the above and the favourable response obtained at that time, and upon accepting INVAP the challenge of designing, constructing and implementing the first radars developed in our country, ANAC decided to engage its services to develop a ground-based GNSS signal augmentation system – GBAS.

1.8 It should be noted that, for this development, consideration was also given to the long history of scientific research in the field of GNSS systems and tropospheric/ionospheric phenomena of the School of Astronomical and Geophysics Sciences of the University of La Plata, which provided the academic correction algorithms and defined the local parameters required to mitigate the phenomena and anomalies of our South American region.

1.9 The decision of the Argentinian State to adopt a ground-based augmentation system was made within the context of the decision made by most Latin American civil aviation authorities to reject the European proposal of having an augmentation service based on a satellite platform (SACCSA – augmentation system for the Caribbean, Central America and South America). This model entailed high initial and operational costs, as well as high technological dependence.

1.10 Accordingly, compared with other precision approach systems, GBAS offers many benefits and, thus, has been given priority among possible alternatives, which include:

- Reduction of critical and sensitive zones;
- Curved approaches;
- Positioning service;
- Service provided in several runways of the same airport using the same equipment;
- Reduction of gas and noise emissions;
- Provision of several approach gliding angles and displaced threshold;
- Missed approach with guidance; and
- Use in adjacent airports.

1.11 In summary, the decision was made to implement PBN in continental airways and GBAS for precision approach Cat I, to be replaced in the future by ILS systems, in accordance with the ICAO strategy set forth in the *Global air navigation plan*.

2. Timeline of the Argentinian GBAS project

24/01/2014	Document signed to start the first stage	Design, manufacturing, implementation and standardisation of a system at the international airport of San Carlos de Bariloche.
	Technological evaluation lab model	a) Generation and transmission of simulated position signal with precision-only correction. b) Integrity, continuity and operational availability algorithm in a lab environment. c) Data collection for analysis and reliability statistics.
24/06/2016	Technological evaluation model on the site	a) displacement of fences and perimeter road at the implementation site of the Bariloche airport. b) Implementation of four reference stations. c) Laying of feeder lines and FO control d) Data collection and determination of site parameters. e) Trial implementation of the signal processing and VDB transmission centre.
	Certification and standardisation process	A manual that defines the certification procedure and demonstrates that the GBAS system meets the relevant standards has been drafted. This procedure will facilitate product standardisation.
24/06/2017	First trial period	Initial, statistic. Data received at the local monitoring station will be stored and analysed.
12/2018	Second trial period	Advanced, aircraft. Data received on the aircraft MMR will be stored and analysed.
2019	Certification and standardisation	Calibration of monitors, external certification of the product, product standardisation, operational certification.
2020	Document signed to start the second stage	Manufacturing and implementation of six systems at airports to be defined.

3. Characteristics of the Argentinian GBAS system

3.1 The system has four antennae and GPS receivers that make up the reception system, a booth with central electronics consisting of two processing channels and a redundant transmission system, and one VDB antenna. In order to verify the pseudo-correction values, an antenna and a receiver were installed in the surroundings of the airport. The purpose of the system is to provide Cat I approach and positioning services.

3.2 The installation was done in accordance with the recommendations of FAA Order 6884.1, and the provisions of ICAO Annex 14 for implementation at aerodromes.

3.3 In addition to the installation at the airport, a test bed was installed at INVAP labs in Bariloche, consisting of:

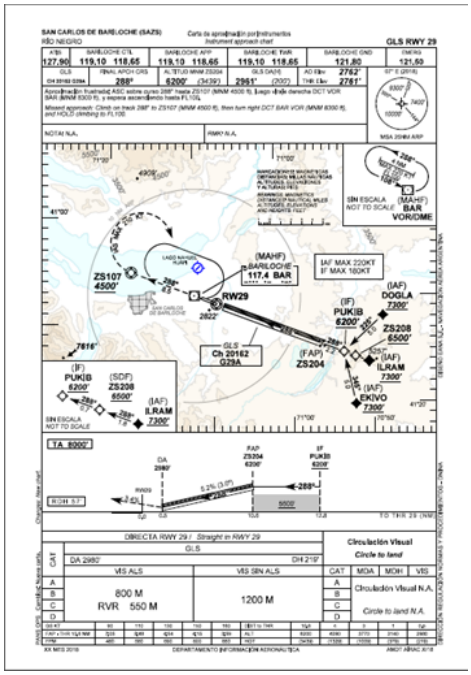
- Constellation simulator
- GPS receivers
- A processing unit with the algorithm for pseudo-correction, integrity control and assembly of messages type 1, 2 and 4

- VDB transmitter
- VDB receiver
- A GBAS frame analyser

4. Current status

4.1 The ground segment, made up by the shelter with the electronic equipment plus the reference receivers and the VDB transmitter antenna, is fully operational at the local airport.

4.2 In early 2018, the *Empresa Argentina de Navegación Aérea EANA S.E.* was requested to develop the approach chart for threshold 29, together with FAS data to be transmitted through the GBAS-SINAL system. The following graph describes the IAC GLS RWY 29 procedure for the San Carlos de Bariloche (SAZS) aerodrome, which was validated on ground by the National Directorate of Air Navigation Inspection (*Dirección Nacional de Inspección de Navegación Aérea*) of ANAC, for exclusive use in the system certification process.



4.3 At the same time, an agreement was signed between INVAP and *Aerolíneas Argentinas S.A.* to design a plan to verify the proper operation of the system, taking advantage of the installed capacity on board Boeing 737-800SFP and MAX aircraft equipped with Multi-Mode Receiver - MMR, which permits the reception of the GBAS signal.

4.4 *Aerolíneas Argentinas* and the National Safety Bureau of ANAC analysed and defined the safety plan for safe CAT I ILS approach operations with data capture and GLS information display.

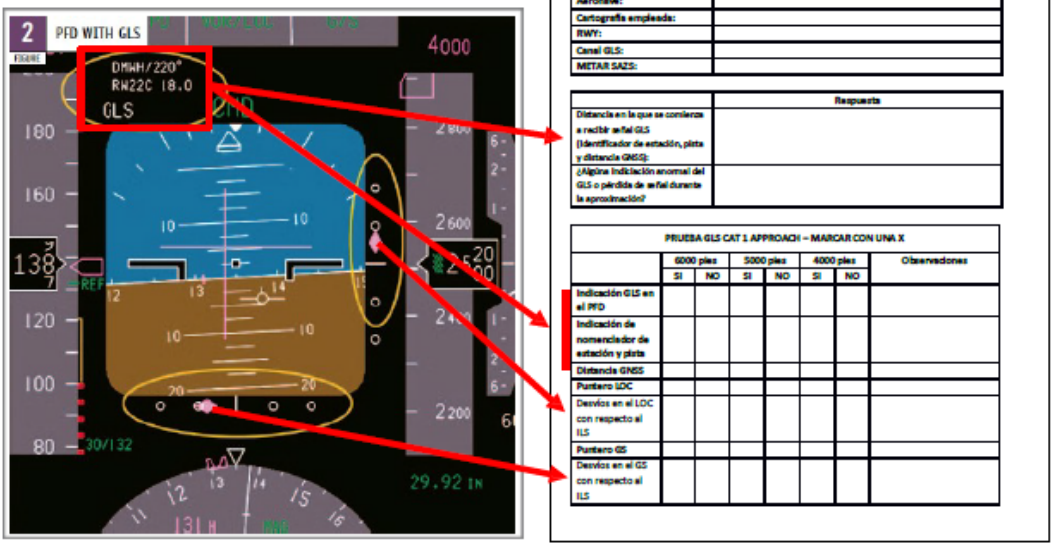
4.5 Authorised procedure:

- The PF (pilot flying) will use the ILS approach mode according to the published charts. The PM (pilot monitoring) will conduct the following tests WITHOUT ever engaging the autopilot on the test side (if the PM is the commander, he/she must not use the AP A; if the PM is the co-pilot, he/she must not use the AP B).
- VMC conditions.
- Cross-wind component of less than 20 knots.

The request is to:

- Select the channel in MMR mode GLS prior to Top of Descent (T/D).
- Data capture at 6000/5000/4000 feet of pressure type altimeter. Compare LOC/GS with ILS information.
- After landing, take note of any observation or abnormality in the GLS during approach

4.6 Flight validation template – GLS SAZS: Complete the DATA prior to starting the descent.

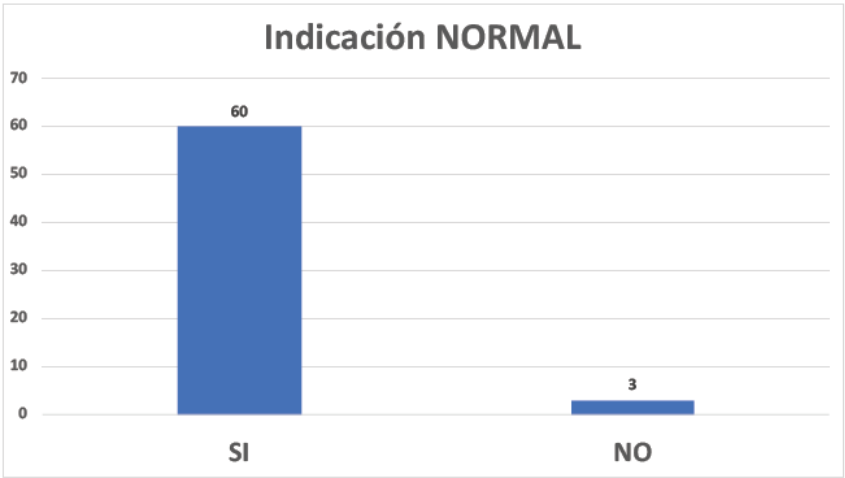


4.7 Thus, on 28 June 2018, for the first time in Argentina, a CAT I approach was performed to threshold 29 of the San Carlos de Bariloche airport, receiving GLS information from the GBAS station installed therein. Images obtained in the PFD (Primary Flight Display) are shown below.

4.8 **Results**

4.8.1 The results obtained in 63 approaches are shown.

- NORMAL indication during approach:



- Normal indications in aircraft instruments in 95% of approaches.

- The 3 cases in which there was no complete or normal indication were:

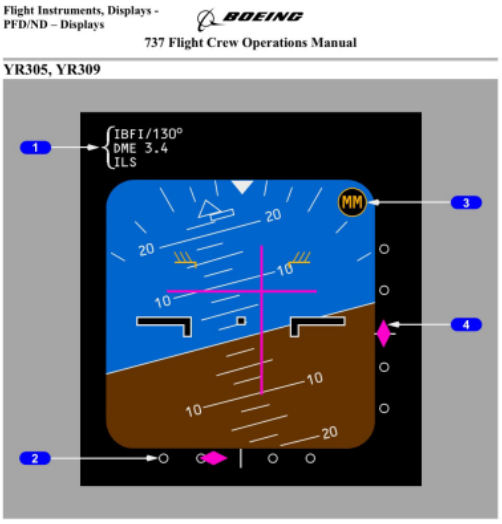
  - 30 November 2018: the system was disconnected.
  - 8 February 2019: on this day, there was a scheduled power outage reported by INVAP.
  - 9 February 2019: on this day, there was a scheduled power outage reported by INVAP.

- It should be noted that, in the 3 cases, there was no indication from the GLS.

  - Lack of indication of station NOMENCLATOR (G29A):

- It was reported that the runway nomenclator did not show on the primary flight display (PFD) and instead the channel number was shown in yellow and crossed out. This is normal because, upon approaching with two types of stations selected at the same time (ILS the pilot flying and GLS the pilot monitoring), the aircraft notes the discrepancy and thus they are crossed out and the station nomenclators appear in yellow.

4.8.2 An extract of the aircraft Flight Crew Operations Manual explaining this is shown below:



1 Approach Reference

YC069, YC730, YN102 - YN110, YR416 - YS518, YV601 - YW976
Displays the selected ILS frequency or identifier, approach course, ILS/DME/FMC distance and source annunciation.

YM241, YM242, YR305, YR309, YT067
Displays the selected ILS/IAN frequency or identifier, approach course, ILS/DME/FMC distance and source annunciation.

YR305 - YS518, YV601 - YW976
Displays the selected GLS identifier, channel, selected course, GLS approach distance and source annunciation.

If the tuned ILS frequencies disagree (for longer than one minute of time), the frequency turns amber with an amber horizontal line until set identically.

If the approach courses entered in the MCP disagree (for longer than one minute of time), the course turns amber with an amber horizontal line through it.

4.9 **Conclusion**

4.9.1 The results showed satisfactory performance of the GBAS station, while distance, glide path, and localizer data are reliable in this first stage.

4.10 **Next steps**

4.10.1 At present, telemetric source monitors are being calibrated to meet integrity, availability and continuity requirements, and the severity of the ionospheric threat is being analysed.

4.10.2 Furthermore, a work agreement is being prepared with a national university to audit compliance with all project requirements for product certification.

4.10.3 Regarding operational certification, work is underway on the safety analysis required for subsequent flight tests.

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