



# ICAO

International Civil Aviation Organization  
North American, Central American and Caribbean Office

SUMMARY OF DISCUSSIONS

## NAM/CAR/SAM Workshop on Radio Navigation (RDNVW2025)

Mexico City, Mexico, 02 to 04 September 2025

### SUMMARY OF DISCUSSIONS

**Date** 02 to 04 September 2025  
**Location** ICAO NACC Regional Office  
**Opening Ceremony** The Workshop was attended by **34** participants (in-person participation) and **113** virtual participations, delegates from **27** States/Territories from NAM/CAR/SAM Regions, four International Organizations and six representatives from the industry. The list of participants is shown in **Appendix A**.



## **1. References**

- 1.1 Invitation – Workshop on Radio Navigation Workshop for NAM and SAM Regions (Ref.: Ref.: NT-N 1-3; LT2/3 E.OSG-NACC115932; SA225-2025).

## **2. Objectives**

2.1 The Workshop aimed at raising awareness on the significant impact of Global Navigation Satellite System (GNSS) Radio Frequency Interference (RFI) on aviation safety, capacity and efficiency. It also provided a venue for discussing challenges and exchanging best practices related to GNSS RFI including its impact and mitigation strategies adopted by various stakeholders. The Workshop also provided an update on the latest developments in the field of radio navigation aids involving GNSS core constellations and augmentation systems and radio navigation flight inspections.

- 2.2 Workshop documentation is available under the following link:

[Radio Navigation Workshop](#)

## **3. Introduction**

3.1 The Radio Navigation Workshop for the North American (NACC) and South American (SAM) Regions brought together aviation professionals, technical experts, and regulatory authorities to address challenges, share developments, and harmonize practices in radio navigation across the Americas. With rapid advances in navigation technologies, evolving regulatory requirements, and growing demands for safety, efficiency, and interoperability, the workshop served as a key forum for assessing current infrastructure, reviewing performance metrics, and charting a path forward.

3.2 Over the course of the workshop, participants examined a range of core topics, including updates to navigation standards, implementation of modern systems (such as GNSS core constellations, augmentation systems, and ground-based aids), and integration of safety-critical services. Presenters highlighted both achievements and gaps in operational capacity, training, and regulatory oversight; case studies provided concrete examples of implementation successes and lessons learned. Equally important, the workshop enabled cross-border collaboration, encouraging harmonization of procedures and regulations among NACC and SAM States to ensure seamless navigation and air traffic flow across regions.

## **4. ICAO Provisions and activities related to radio navigations**

4.1 Under the presentation P/17; ICAO-Global Develop-Roadman's-RFI provided by the Secretariat, the growing challenge of GNSS RFI, its potential consequences, and ICAO's roadmap to counteract GNSS RFI including short-term mitigation measures and mid-term and long-term solutions were underscored.

4.2 Building on key ICAO provisions—Annex 10, the GNSS Manual (Doc 9849), and guidance on spectrum management (Doc 9718) and radio navigation testing (Doc 8071), the session emphasized the need for resilience, protection from harmful interference, and the preservation of conventional navigation aids as contingency. Resolution A41-8/C and the recommendations of the 14th Air Navigation Conference Highlighted States’ responsibilities to implement RFI mitigation measures, develop regional reporting procedures, and strengthen collaboration with industry to enhance aircraft system resilience.

4.3 At the technical level, the presentation outlined important regulatory updates and future solutions. Amendments 94 & 93 to Annex 10, introduced Horizontal Advanced Receiver Autonomous Integrity Monitoring (ARAIM) and Dual-Frequency Multi-Constellation (DFMC) GNSS provisions, respectively. While authentication features such as Galileo Open Service Navigation Message Authentication (OSNMA - 2029) and Satellite Based Augmentation System (SBAS) Authentication (2027) are being developed to counter spoofing risks. ICAO is also promoting Complementary PNT (C-PNT) and the Resilient Operational Network (NAV RON) as solutions to GNSS RFI issue that can ensure sustainable navigation continuity during disruptions. The roadmap sets clear milestones: Implementation Packages (iPack) and regional reporting in 2025, SBAS authentication validation in 2027, GNSS authentication provisions by 2029–2030, and full DFMC operational use between 2032 and 2035. The key message reinforced was that GNSS RFI is a significant safety risk demanding a multi-layered response of regulatory, technological, and cooperative measures, with success hinging on sustained collaboration among States, ICAO, International Telecommunication Union (ITU), International Maritime Organization (IMO), industry, and defence sectors.

## **5. Regional Developments related to NAV**

5.1 Under P/15, an Ad-hoc Group, part of the North American, Central American and Caribbean Working Group (NACC/WG) Communications Task Force (COMM/TF) presented a regional project with the aim to develop an Operational Concept (CONOPS) designed to rationalize and renew conventional navigation aids while ensuring a smooth transition toward GNSS-based services. Covering Central America, Mexico, and the Caribbean, the plan proposes a Minimum Operational Network (MON) of very high frequency (VHF) Omnidirectional Range Distance Measuring Equipment/ Distance Measuring Equipment (VOR/DME), selective Instrument Landing System (ILS) retention, and the dismantling of outdated Nondirectional Radio Beacon (NDBs), alongside progressive deployment of SBAS and ground-based augmentation system (GBAS). The CONOPS will integrate en-route, terminal, and approach needs, balancing efficiency with contingency requirements, and incorporates centralized monitoring for GNSS interference (jamming/spoofing). Its adoption process based on infrastructure assessments, joint needs analysis, and validation through the CAR/SAM Planning and Implementation Regional Group (GREPECAS) —aligns closely with ICAO’s global resilience roadmap. The first version will be presented at the next GREPECAS meeting.

## 6. GNSS Augmentation System

6.1 Presentation P/06 by EUROCONTROL, with contributions from Stanford University, FAA, and the EU Space Programme, outlined the evolution from traditional Receiver Autonomous Integrity Monitoring (RAIM) to Advanced RAIM (ARAIM) as the cornerstone for robust GNSS operations. While classical RAIM (global positioning system/GPS L1-based) has supported air transport for decades, it suffers from limitations in transparency, dependency, and vulnerability. ARAIM builds on multiple constellations (GPS, Galileo, GLONASS, BeiDou) and dual frequencies to provide higher integrity, redundancy, and global coverage, enabling advanced Performance-Based Navigation (PBN) and vertical guidance such as LPV200/Cat I approaches

6.2 The roadmap foresees Service Type A (H-ARAIM) around 2026, using default Integrity Support Data (ISD), and Service Type B (V-ARAIM) by 2030, enabling global vertical guidance with standardized Integrity Support Messages (ISM). Benefits include harmonized error models, improved transparency in constellation performance, and oversight mechanisms separating constellation providers from integrity monitoring generators. Ultimately, ARAIM ensures interoperability, resilience, and redundancy, positioning it as a critical enabler of future GNSS-based aviation operations worldwide

6.3 Under P/13, Dominican Republic shared its experience with the implementation of the GBAS at Punta Cana International Airport (MDPC) as a modern alternative to the traditional ILS. In line with ICAO recommendations promoting GNSS augmentation systems, GBAS enhances satellite signals to enable precision GLS approaches (GLS stands for GBAS Landing System), already operational at multiple runways ends (08, 09, 26, 27). The system provides flexible trajectories, lower infrastructure costs, reduced environmental impact, improved efficiency, and enhanced capacity, while supporting operations in low-visibility conditions

6.4 Operational monitoring is conducted through the Air Traffic Status Unit (ATSU), which displays system modes: normal (approaches available), alarm (service unavailable), test (maintenance), predicted outage, and warm-up periods. Currently, 20–25% of aircraft at MDPC are already using GLS approaches, demonstrating early adoption and the operational value of GBAS in the Caribbean. The experience confirms GBAS as a viable, cost-effective, and environmentally friendly solution for advancing navigation services in the region.

6.5 Under P/16, INDRA and the Task Force for SBAS Latam implementation highlighted the role of SBAS in enhancing GNSS performance for aviation, improving accuracy, integrity, availability, and continuity. SBAS provides Safety of Life services, enabling precision approaches localizer performance with vertical guidance (LPV) without the need for costly ILS installations, reducing fuel consumption, delays, diversions, and CO<sub>2</sub> emissions while increasing airport accessibility and operational efficiency.

6.6 The evolution of the SBAS LATAM initiative was reviewed, from early testbeds (CSTB, EDISA) and the SACCSA studies, to its designation as a strategic priority by GREPECAS, and more recent EU-supported projects (SCENIC, EU-LAC APP II). These efforts addressed technical barriers such as equatorial ionospheric disturbances and built strong regional capacity. The 2025 EASA Workshop in Peru marked a turning point, establishing an SBAS LATAM Working Group to define governance, ionosphere monitoring, demonstrations, cost-benefit analyses, training, and a deployment roadmap. With global SBAS programmes (EGNOS, WAAS, MSAS, GAGAN, KASS, etc.)<sup>1</sup> as reference, Latin America now has both the technical maturity and institutional momentum to move from studies to actual SBAS implementation.

6.7 Under P/14, the Secretariat presented information about the World Radiocommunication Conference (WRC-27) preparation, emphasizing that aeronautical Communications, Navigation and Surveillance (CNS) systems depend on reliable and interference-free frequency spectrum, which is a scarce natural resource under growing demand. Over 1 GHz of spectrum is globally allocated to aviation safety services, supporting critical functions such as air traffic control communications, navigation aids, collision avoidance, weather radar, and radio altimeters. Effective spectrum management is essential to ensure operational safety and efficiency, requiring aviation to actively defend its interests in international regulatory forums.

6.8 Central to this process are the International Telecommunications Union (ITU) WRCs, held every four years, where the international community revises the Radio Regulations and decides on spectrum allocations. The upcoming WRC-27 will address key agenda items relevant to aviation, including protection of radio altimeters (critical for safety), modernization of aeronautical high frequency (HF) services, spectrum for space weather sensors, and beyond-line-of-sight C2 links for RPAS. ICAO urged States to adopt a common aviation position, ensure the participation of civil aviation experts in national and regional preparations, and firmly support ICAO's spectrum strategy (Assembly Resolution A41-7). The message was clear: aviation cannot expect preferential treatment at the ITU, success depends on strong preparation, active engagement, and unified representation to secure spectrum vital for current and future CNS/ATM (Air traffic management) systems.

## **7. Update Core Constellation**

7.1 Under P/07, the European Commission updated the information about the Galileo Programme; currently has 32 satellites in orbit, with 27 supporting navigation and 28 contributing to Search and Rescue (SAR). Recent upgrades include a major system migration (SB2.0), expansion of ground infrastructure (new station in Bonaire, upgrades in Europe, redundancy improvements), and preparations for the next generation (G2G).

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<sup>1</sup> EGNOS: European Union SBAS  
WAAS: Wide Area Augmentation System of United States  
MSAS: Multi-functional Satellite Augmentation System of Japan  
GAGAN: GPS Aided GEO Augmented Navigation of India  
KASS: Korea Augmentation Satellite System

7.2 Galileo now delivers a wide range of services: the Open Service, the Public Regulated Service (PRS), SAR with return link, the High Accuracy Service (HAS) providing free decimeter-level precision worldwide, and authentication features to counter spoofing. In July 2025, the OSNMA became operational, with aviation adoption expected under ICAO SARPs by 2026. The Signal Authentication Service (SAS) will begin in 2027, completing robust protection against spoofing. Additional initiatives include the Emergency Warning Satellite Service (EWSS), entering service in 2026, and proposals under the European Competitiveness Fund (2028–2034) to expand into LEO-PNT satellites. Overall, Galileo is evolving into a multi-service, resilient PNT system, strongly driven by aviation requirements such as Safety of Life, authentication, and global distress tracking.

## **8. GNSS Vulnerabilities and emerging trends**

8.1 Under P/02, EUROCONTROL highlighted the growing threat of GNSS interference and spoofing for aviation operations. While GNSS constellations and augmentation systems are generally robust, interference has escalated in recent years from occasional disruptions to a daily operational issue in some regions. Reports from EASA and EUROCONTROL’s EVAIR system confirm thousands of GNSS-related incidents in 2024, including over 500 spoofing cases. Monitoring Automatic Dependent Surveillance – Broadcast (ADS-B) and Multilateration shows persistent hotspots over the Eastern Mediterranean, Black Sea, and Baltic, with effects now spreading into Western Europe. Spoofing can cause lasting navigation errors, with some aircraft unable to recover accurate positioning until well into oceanic airspace.

8.2 Operational impacts are severe, with cascading failures across navigation, surveillance, and communications systems. Affected functions include ADS-B, Controller Pilot Data Link Communications (CPDLC), Stands for Ground Proximity Warning System/ Enhanced Ground Proximity Warning System (GPWS/EGPWS), synthetic vision, weather radar, and even emergency locator transmissions. In some cases, aircraft experience false terrain alerts leading to unexpected go-arounds or uncoordinated manoeuvres, fundamentally undermining cockpit principles of trusting instruments and standard operating procedures. Civil aircraft remain especially vulnerable compared to military systems, with even low-power jammers able to disrupt operations over wide areas. The conclusion stressed that GNSS interference is no longer just a contingency, it is becoming part of normal operations in certain regions, requiring independent Communication, Navigation, Surveillance and Spectrum (CNSS) elements, resilient navigation strategies, and stronger international coordination to manage extended risk exposure.

8.3 Under P/05, United States highlighted the growing scale of GNSS spoofing and interference impacting civil aviation. Spoofing surged from ~300 daily cases in early 2024 to peaks of ~1,500 per day by August, with disruption rates rising 65% year-on-year. Reports confirm widespread signal loss and degraded navigation, especially affecting oceanic operations, where reliance on Automatic Dependent Surveillance — Contract (ADS-C) and HF voice becomes compromised. Impacts include loss of Satellite Communications (SATCOM), degraded positional accuracy, time/date shifts in CPDLC messages, and reduced efficiency due to increased separation standards. This results in higher controller workload and decreases situational awareness.

8.4 At the aircraft level, GNSS interference can cause cascading failures across navigation, communications, and surveillance systems, including ADS-B, Terrain Awareness and Warning System (TAWS), runway awareness, synthetic vision, SATCOM, and Electronic Flight Bag (EFB) displays, forcing reliance on conventional aids and radar vectors. The FAA stressed that GPS resiliency requires a layered approach combining training, policy, technical mitigations, and strong reporting mechanisms. Coordination with international partners, In the context of aviation, Original Equipment Manufacturer (OEMs), and operators is essential to address both current and evolving threats, including the potential shift to targeted spoofing with catastrophic consequences. The FAA's Safety Alert for Operators (SAFO 01/25/24) reinforced the need for awareness, reporting, and collaborative mitigation strategies.

8.5 Under presentation P/12, Brazil, through Department of Airspace Control in Brazil (DECEA), presented its national plan to implement a NAV MON as a resilience measure against increasing GNSS disruptions. The plan builds on ICAO recommendations and national directives (DCA 351-7, 2025), ensuring that conventional navigation aids (VOR/DME, ILS) and DME/DME/Inertial combinations provide a robust contingency framework. The MON will secure continuity of operations during GNSS failures, maintaining in-route RNAV5 (Area Navigation) procedures, Standard Instrument Departure/Standard Terminal Arrival (SID/STAR) operations within DME coverage, and conventional approaches at major and strategic airports.

8.6 The strategy includes rationalization of NDB and VOR networks, reinforcement of DME/DME infrastructure, contingency planning at ACC/APP/CGNA, and publication of MON procedures by the cartography authority. Implementation prioritizes the 40 busiest airports, state capitals, and military bases, supported by training and simulation exercises. While challenges remain due to Brazil's continental scale and remote areas, the MON plan strengthens safety, operational continuity, and environmental efficiency, complementing PBN deployment and supporting ICAO's global resilience framework.

8.7 Under P/03, EUROCONTROL outlined a comprehensive approach to mitigating GNSS RFI, recognizing vulnerabilities from both intentional (jamming/spoofing) and unintentional sources (equipment failures, spurious emissions). Short-term measures include improved reporting, pilot guidance (“GPS weather” awareness tools), operational support through ATC, and maintaining resilient infrastructures such as MON and ILS. Medium- to long-term strategies emphasize Complementary PNT (C-PNT), multi-sensor integration (DFMC GNSS, DME/DME, inertial systems), and robust standards under development by EUROCAE/RTCA.

8.8 The presentation stressed the importance of regulatory engagement and evidence-based reporting, encouraging States to escalate unresolved interference cases to the ITU. EUROCONTROL also demonstrated airspace risk assessment tools and the development of GNSS receiver reporting to provide real-time interference status. The key message was that resilience requires layered solutions, combining technical innovations, regulatory cooperation, pilot/operator awareness, and redundant CNS/ATM infrastructure to ensure safe and efficient air navigation despite GNSS disruptions.

8.9 Under P/09, Argentina reported on GNSS interference events that occurred at Aeroparque Jorge Newbery (Buenos Aires) between late 2017 and mid-2018, affecting multiple aircraft types (B737, B737NG, E190) and causing failures in avionics systems used for GNSS-based procedures. The interference led to degraded operational safety, triggering an investigation by ANAC in coordination with the telecommunications authority and airlines. Technical inspections between May and September 2018 included in-cabin checks, ramp surveys, and mobile tracking, which identified unauthorized mobile devices and private radio stations as interference sources.

8.10 Mitigation actions included awareness campaigns for the aeronautical community, stricter controls of private mobile stations at airports, coordination with the telecom regulator for preventive monitoring, and maintaining historical GNSS performance logs. Additional recommendations were made for greater reliance on DME/DME as an alternative navigation aid, periodic evaluations under the National safety programme (PNSO), and updates to regulations to strengthen prevention. The case demonstrated the need for systematic monitoring and cross-agency coordination to manage GNSS vulnerabilities.

8.11 Under P/18, IATA stressed that GNSS RFI has become a global safety risk, with hotspots not only in conflict-adjacent FIRs but also in the SAM Region (notably FIRs Ezeiza, Resistencia, Brasilia, and Recife) and recent operational issues in Brasilia and Mexico City terminal control areas (TMAs).

8.12 Recommendations focused on Air navigation services provider (ANSPs) and States: promptly notify airlines when interference occurs, inform crews and controllers, coordinate with spectrum regulators, and establish effective monitoring, reporting, and contingency procedures. IATA emphasized the need to retain conventional navigation aids (ILS/DME, VOR/DME) as part of NAV MON, while phasing out unsupported NDBs. The organization called for strong collaboration under ICAO frameworks, reinforced spectrum protection, and balanced CNS rationalization to ensure operational resilience against GNSS vulnerabilities.

8.13 Under P/08, Argentina presented an analysis of GNSS interference events in the SAM Region between January 2024 and July 2025, using data from GPSJAM and Stanford University's monitoring platforms, complemented by IATA safety assessments. The study confirmed that while spoofing and jamming cases remain relatively few at the regional level, recurrent hotspots and extended patterns of events are evident across South America, with impacts detected in multiple flight phases.

8.14 The conclusions stressed the need to continue systematic monitoring and reporting, identify interference sources, and maintain a conventional radio aid network (e.g., DME/DME, VOR/DME, ILS) as contingency against GNSS disruptions. Preventive measures, corrective actions, and regional guidance material were recommended to consolidate lessons learned and enhance operational resilience in the SAM Region.

8.15 Under P/10, ICAO presented the outcomes of its recent regional radio navigation activities focused on GNSS RFI awareness and mitigation. Following recommendations from AN-Conf/14, ICAO has organized a series of regional workshops and symposia: EUR/MID Symposium (Feb 2024), ACAO/ICAO Workshop in Morocco (Feb 2025), APAC Symposium (Apr 2025), and now the NAM/SAM Workshop (Sept 2025).

8.16 These events aimed to raise awareness, share mitigation strategies, and develop standardized reporting procedures for GNSS interference. Key outcomes include the drafting of regional RFI reporting procedures, the identification of technological and procedural gaps, and the publication of Electronic Bulletin EB2025/20 to disseminate recommendations globally. ICAO emphasized the need for States to adopt these measures, strengthen civil–military and regulatory coordination, and contribute to a unified global approach to addressing GNSS vulnerabilities.

8.17 Under P/01, ROHDE & SCHWARZ highlighted how Unmanned Aircraft Systems (UAS), combined with the R&S®EVSD1000 Nav/Drone Analyzer, are modernizing ground inspections of navigation aids (ILS, VOR, DME, (UHF) tactical air navigation aid/TACAN). By complementing or replacing traditional ground check vehicles, these drone-based solutions provide greater flexibility, lower costs, reduced environmental impact, and faster deployment, while ensuring high accuracy and ICAO compliance (Annex 10, Doc 8071).

8.18 Techno Sky (ENAV Group) shared its operational experience in Italy, where UAS are already authorized for ILS ground checks under Beyond Visual Line of Sight (BVLOS) conditions. The drones, equipped with multisensor payloads, autonomously capture signal-in-space data for localizer and glidepath verification, producing automated reports aligned with ICAO tolerances. Benefits include quicker runway clearance, better correlation with flight inspection results, and lower maintenance demands. The program is expanding to major airports like Milan Malpensa and Rome Fiumicino, with future upgrades for autonomy, fleet growth, and centralized drone operations—showcasing UAS as a sustainable, efficient, and safe innovation in navigation aid inspection.

## **9. Radio Navigation Flight Inspection**

9.1 Under P/04, the Rapporteur of ICAO Conventional Navigation and Testing Working Group (CNTWG) presented ICAO provisions related to radio navigation flight inspection (Annex 10, Doc 8071) requiring periodic flight and ground tests of navigation aids to ensure compliance and safety. It highlighted updates to Doc 8071, including new guidance on reducing flight inspection runs (especially for ILS) and upcoming material on UAS-based inspections. While drone operations (Visual line-of-sight/VLOS and BVLOS) show promise for cost-effective and flexible measurements, they are seen as a complement to traditional flight inspection, not a replacement.

9.2 Flight inspection remains essential for detecting multipath, antenna faults, and propagation issues that ground checks cannot capture. Modern ILS, supported by strong maintenance and site safeguarding, can justify reduced periodicities, but integrity still depends on robust monitoring and flight checks. With GNSS RFI emerging as a new challenge, flight inspection aircraft, potentially equipped with direction-finding arrays and CRPA antennas, could also play a key role in detecting and localizing interference sources. The conclusion reaffirmed that conventional aids, particularly ILS, remain indispensable, and that evolving technologies, including drones and advanced sensors, will strengthen resilience and efficiency in navigation aid oversight.

9.3 Under P/19, the Secretariat explained how the Universal Safety Oversight Audit Programme (USOAP) evaluates States' compliance with Annex 10 and Doc 8071 provisions on flight inspections of radio navigation aids. Audits assess whether States have proper legislation, regulations, qualified personnel, certified equipment, and oversight systems to ensure periodic flight inspections are conducted and documented. A Priority Protocol Question (PPQ 7.393) specifically checks if States establish requirements and provide regular inspections for NAVAIDs, with non-compliance potentially leading to Significant Safety Concerns (SSCs)

9.4 Key recommendations included: establishing clear regulations and oversight, maintaining risk-based inspection schedules, ensuring qualified and recurrently trained personnel, applying standardized ICAO procedures and certified equipment, and strengthening reporting, corrective actions, and regional cooperation. ICAO emphasized that deficiencies in these areas remain a major source of SSCs globally, highlighting the need for States to demonstrate evidence of effective flight inspection programmes to safeguard air navigation services.

9.5 **Appendix B**, includes a summary of recommendations on radio navigation flight inspection.

## 10. **Group Activity-Developing Regional Reporting Procedure on GNSS RFI**

10.1 As part of the workshop, participants engaged in an activity to draft a regional GNSS RFI reporting procedure for the NAM and SAM Regions, in line with AN-Conf/14 Recommendation 2.2/2e and ICAO's GNSS Manual (Doc 9849). The exercise was aimed at creating a framework that would raise operational awareness of affected geographical areas and ensure consistent reporting across States

10.2 The activity was structured into several steps: identifying the need and objectives of an RFI reporting procedure, mapping the stakeholders involved (pilots, ATC, CNS, CAAs, ICAO, telecom regulators, ITU, military), defining their roles, and designing a communication and escalation chain. Participants worked in small groups by profession and language, with each group presenting outcomes to the plenary. The expected result was a draft reporting procedure for review, refinement, and eventual endorsement by planning and implementation regional group (PIRGs), consolidating diverse perspectives into a unified regional approach.

10.3 The **Appendix C** provided a summary of the group discussion.

## 11. **Outcomes and Recommendations**

11.1 Outcomes: the following topics were discussed during the workshop and delegates provided active participation:

- GNSS vulnerabilities: Interference and spoofing have become daily operational issues, degrading navigation, surveillance, and communications (Argentina, Brazil, United States, Eurocontrol, IATA).
- ICAO global roadmap: Introduced GNSS RFI mitigation packages (iPack), new SARPs (Annex 10 Amendment 94), and future resilience measures (DFMC GNSS, ARAIM, authentication, C-PNT).
- Spectrum protection: WRC-27 will decide on allocations affecting aviation, including radio altimeters, HF modernization, RPAS C2 links, and space weather sensors.
- Regional initiatives: Brazil and COCESNA presented MON/CONOPS frameworks to balance GNSS with conventional aids. Argentina highlighted lessons from GNSS disruption events.
- Augmentation systems: Dominican Republic (GBAS) and Indra (SBAS LATAM) confirmed technical maturity and benefits, while Galileo showcased authentication and new services (OSNMA, SAS, EWSS).
- Innovation in inspections: UAS-based inspections (Techno Sky/ENAV) and updated ICAO/ EUROCONTROL guidance show drones as a complement to traditional flight inspection.
- Oversight: ICAO's USOAP audits stress States must prove regulatory compliance, proper scheduling, trained staff, and reporting for flight inspections.

#### 11.2 Recommendations:

##### **States/ANSPs:**

- Implement GNSS RFI mitigation and reporting (ex. Doc 9849)
- Maintain a NAV MON of VOR/DME/ILS; progressively retire NDBs, and implement NAV resilient operational network (NAV RON) once rolled out.
- Promptly notify operators of GNSS disruptions, issue NOTAMs, and coordinate with spectrum regulators.
- Ensure qualified inspectors, certified equipment, and recurrent training for flight inspections.

##### **ICAO/Regional groups:**

- Deliver GNSS RFI iPack (2025) and finalize SARPs for SBAS authentication, ARAIM, DFMC GNSS.
- Promote regional SBAS deployment and harmonized GBAS rollout.
- Strengthen global spectrum protection and integrate aviation needs at WRC-27.

**Industry/Operators:**

- Adopt new GNSS resilience technologies (OSNMA, SBAS, ARAIM).
- Support innovation in inspections (UAS, advanced sensors) and provide operational input for NAVAID rationalization.
- Train crews on RFI awareness and contingency procedures.

**12. Accomplishments**

12.1 The workshop successfully combined global strategies with regional actions, delivered practical lessons from States, and showcased technological innovations that together advance the safety, efficiency, and resilience of navigation services in the NAM/CAR/SAM Regions.

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North American, Central American and Caribbean Office (NACC)  
Oficina para Norteamérica, Centroamérica y Caribe (NACC)

**NAM/CAR/SAM Workshop on Radio Navigation**  
**Taller sobre Sistemas de Navegación aérea para las regiones NAM/CAR/SAM**  
**(RDNVW2025)**

Mexico City, Mexico, 2 to 4 September 2025 / Ciudad de México, México del 2 al 4 de septiembre de 2025

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## APPENDIX B

### ICAO Annex 10 – Inspections of VOR/DME Systems Ground Checks vs. Flight Inspections

A VOR/DME has several parameters that can be verified and measured on the ground without requiring flight inspection. These **ground checks** are part of **preventive maintenance** and **technical installation verifications**.

#### Parameters of VOR measurable on the ground

- Operating frequency: confirmation of assigned frequency.
- Transmission power: verification of RF output power.
- Morse code identification: clarity, periodicity, and correctness of transmitted ID.
- Frequency channelization and stability: compliance with ICAO Annex 10 tolerances.
- Phase of carriers (30 Hz reference and variable signals): measurable with bench test equipment.
- Signal-to-noise ratio and harmonic distortion: to ensure audio quality of the ID channel.
- Radial simulation on test bench: confirm that generated signals correspond to the correct azimuths.

#### Parameters of DME measurable on the ground

- Operating frequency (paired with VOR channel).
- Transmission power: transponder output level.
- Morse code identification: correctness and clarity.
- Fixed delay time (microseconds): within ICAO tolerance.
- Stability and repeatability of the response: using ground DME tester.
- Pulse repetition frequency (PRF): within ICAO specifications.

### Limitations of ground measurement

The following cannot be fully verified without flight inspection:

- Accuracy of radials throughout the service volume.
- Distortions due to multipath or reflections.
- Radial switching zones.
- Real operational coverage and range of the DME.

Therefore, **flight inspection** remains the only ICAO-recognized method to validate airborne signal quality against operational tolerances.

### VOR/DME Parameters – Ground vs. Flight Verification

System	Ground-verifiable parameters	Parameters requiring flight inspection
VOR	Frequency, power, Morse ID, frequency stability, 30 Hz phase, S/N ratio & distortion, bench radial simulation	Radial accuracy, service volume coverage, multipath/reflection effects, radial switching zones
DME	Frequency, power, Morse ID, fixed delay, stability/repeatability, pulse repetition frequency (PRF)	Real distance accuracy, coverage by altitude and sector, interference/multipath evaluation

### Use of Commercial Flights (“Opportunistic Flights”)

It is possible to take advantage of **commercial flight operations** to obtain partial information on the performance of VOR/DME systems, but with **significant limitations**.

#### What can be assessed using commercial flights

- **Real coverage and range:** correlating aircraft positions (radar/ADS-B) with VOR/DME reception.
- **Coverage by altitude and sector:** analysing performance in climbing, cruise, and descent profiles.
- **Detection of anomalies/interference:** pilot reports or discrepancies between indicated and actual position.

**Limitations**

- Not ICAO-recognized: only **calibrated flight inspection aircraft** certify accuracy, reliability, ID, and delays.
- Partial coverage: commercial routes do not provide systematic radial/altitude sampling.
- Data depends on pilot reports: less precise than calibrated measurements.

**Practical Use**

Commercial flight data can be useful as **complementary validation** to:

- Detect degradation trends.
- Verify general coverage after maintenance.
- Provide preliminary evidence before programming official flight inspection.

**Comparison of VOR/DME Verification Using Commercial Flights**

Commercial flight-based verification	Requires official flight inspection
General signal coverage (range)	Bearing accuracy of radials
Coverage by altitude/sector	Morse ID verification
Detection of anomalies/interference	Radiated power & waveform verification
Preliminary DME distance validation	DME delay and accuracy with calibrated equipment
Qualitative assessment of operational reliability	Systematic monitoring of all radials and sectors

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## APPENDIX C

### Group Activity - Developing Regional Reporting Procedure on GNSS RFI

#### 1. The Need for GNSS RFI Reporting Procedure

GNSS is critical for aviation safety and efficiency (navigation, surveillance, ADS-B, PBN). Interference—whether unintentional (faulty transmitters, jammers) or intentional (spoofing, military activities)—can degrade signals, cause navigation loss, and threaten safety.

A formal reporting procedure is necessary to:

- Standardize how interference events are reported.
- Ensure timely detection and mitigation.
- Facilitate regional and global monitoring through ICAO/ITU frameworks.
- Support data collection for trend analysis, resilience strategies, and policy/regulatory action

#### 2. Objective of the Proposed Procedure

- Provide a consistent mechanism for pilots, ATC, and technical staff to report suspected GNSS interference.
- Ensure that relevant authorities (ANSP, CAA, TRA, ICAO) are informed rapidly.
- Support safety risk management by escalating serious cases.
- Feed into global monitoring databases (ICAO, ITU) for long-term mitigation strategies.
- Enhance regional cooperation for cross-border interference events.

#### 3. Stakeholders Involved

- Pilots
- Air Traffic Controllers (ATC)
- CNS/ATM Technical Units (ANSPs)
- Civil Aviation Authorities (CAA)
- ICAO Regional Offices / HQ
- National Telecommunication Administration (TRA)
- International Telecommunication Union (ITU)
- Military / Defense Authorities (MIL)
- Aircraft Operators / Airlines
- Industry Providers (Avionics / GNSS equipment)

#### 4. Roles of Each Stakeholder

- Pilots: Detect and report anomalies via ATC (position loss, RAIM warnings, GPS unavailable).
- ATC: Record reports, assess operational impact, notify CNS/ANSP technical staff and escalate.
- CNS/ANSP Technical Units: Analyse reports, correlate with monitoring data, identify possible interference sources.
- CAA: Coordinate national response, ensure safety oversight, and consolidate reports to ICAO.
- ICAO: Collect and analyse regional/global data, coordinate with States, issue advisories and guidance material.
- TRA: Investigate RF spectrum misuse, coordinate with ITU, take enforcement actions.
- ITU: Maintain global spectrum coordination and protection measures.
- MIL: Coordinate with civil side when interference is caused by authorized exercises; provide timely NOTAM coordination.
- Airlines/Operators: Feedback to crews, coordinate reports with regulators, support investigations.
- Industry Providers: Provide technical support on equipment behaviour and resilience solutions.

#### 5. Reporting Form – GNSS Manual

- The ICAO GNSS Manual (Doc 9849) provides a sample reporting form. Key mandatory fields:
- Date/time (UTC)
- Flight identification / callsign
- Aircraft position (lat/long, altitude)
- Phase of flight
- Type of GNSS equipment installed
- Nature of anomaly (loss of signal, misleading guidance, RAIM alert, etc.)
- Duration of event
- Weather/atmospheric conditions
- ATC sector and frequency in use
- Pilot remarks
- Proposed improvement: Add dedicated fields for:
- Possible geographic reference (map coordinates).
- Effect on aircraft operations (rerouting, procedural separation, workload increase).
- Severity assessment (minor, significant, hazardous).
- Follow-up contact info for CNS/CAA.

## 6. Chain of Communication & Escalation

- Pilot → ATC: Immediate in-flight report of GNSS anomaly.
- ATC → ANSP CNS Unit: Record event, notify technical services.
- ANSP CNS Unit → CAA: Analyse data, determine if RFI suspected.
- CAA → TRA: Escalate if interference is confirmed/suspected (to trace source).
- CAA → ICAO Regional Office: Share report for regional/global database.
- TRA ↔ ITU: Coordinate spectrum protection and enforcement measures.
- CAA ↔ MIL: If interference linked to military activity, establish corrective action (e.g., issue NOTAMs, adjust training zones).
- Escalation levels:
  - Operational level (Pilot ↔ ATC) → immediate impact mitigation.
  - Technical level (ANSP CNS, Airlines) → root cause analysis.
  - National level (CAA, TRA, MIL) → regulatory enforcement.
  - International level (ICAO, ITU) → trend monitoring, cross-border resolution.