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Agenda Item 5: Implementation of CAR/SAM Air Navigation Services (ANS)
5.2 Communication, Navigation and Surveillance (CNS)

PREVENTIVE AND CORRECTIVE MEASURES FOR GNSS INTERFERENCE

(Submitted by Argentine Republic)

EXECUTIVE SUMMARY

This working paper describes the situation of GNSS interference, listing the latest ICAO resolutions and recommendations, the tools currently available, technological advances, and presenting, as an example of a study case, the impact of interference to the GNSS signal that occurred at an airport, concluding in the need to have guidance material at the regional level that allows to gather recommendations on preventive measures and collect information on the corrective measures applied in such events, to make available to the States of the Region.

Action:	It is presented in section 4.
Strategic Objectives:	• Safety • Capacity and efficiency • Economic development
References:	• Resolution A41-7: Support for ICAO's policy on radio-frequency spectrum matters. • Resolution A41-8: Consolidated Statement of ICAO's Standing Policies and Practices for a Global Air Traffic Management (ATM) System and Air Traffic Communications, Navigation and Surveillance/Management (CNS/ATM) Systems Resilience of ICAO's CNS/ATM Systems and Services. • Recommendation 2.2/2 – Interference to the Global Navigation Satellite System and Contingency Planning of the 14th Air Navigation Conference • Fifth Virtual Meeting of the Program and Project Review Committee (CRPP) of GREPECAS (eCRPP/05) • Eighth Workshop/Meeting of the SAM Implementation Group (SAM/IG/8) Study on Coverage Supporting RNAV-5 • Ad-hoc Group for the Development of a Regional Project for the Management of Aeronautical Frequencies

	• GT-INTEROP of SAM/IG • Document Global Navigation Satellite System GNSS Radio Frequency Interference Safety Risk Assessment Version 4 Sep 2024

1. Introduction

1.1 Air navigation using the Global Navigation Satellite System (GNSS) continues to expand, as more and more aircraft are equipped with the necessary avionics and air navigation procedures and PBN routes are also developed and implemented, due to the already demonstrated advantages of this type of air navigation over conventional navigation.

1.2 Interference to GNSS signals and their mitigation is a very present issue and especially considered and studied by ICAO in its forums and documents, since at the international level there have been repeated incidents of interference in GNSS that affect the operational safety of international air navigation, for which all Member States were required to take measures to ensure that the sources of interference are identified and mitigated. GNSS interference signals to ensure that the integrity of international air navigation is maintained.

2 Analysis

2.1 Background. Regulatory Framework. Protection of frequency bands allocated to aeronautical systems

2.1.1 The technical requirements for the characteristics of the signals and on-board equipment used for the Global Navigation Satellite System (GNSS) are set out in Annex 10 – ICAO Aeronautical Telecommunications and related regulations. These parameters define guidelines for design and for GNSS-based air operations. One of the vulnerabilities of the GNSS system is radio interference to signals from the satellite constellation, which can be caused by various sources as detailed in the technical documents that address the subject.

2.1.2 Resolutions A41-7: *Support for ICAO Policy on Radio Frequency Spectrum Matters* and A41-8: *Consolidated Statement of ICAO's Standing Policies and Practices on a Global Air Traffic Management (ATM) System and Air Communications, Navigation and Surveillance/Management (CNS/ATM)* Systems of Assembly 41, express that aviation needs a comprehensive strategy on the radio-frequency spectrum to support the timely availability and appropriate protection of adequate spectrum; and to take measures to address the significant increase in interference events in satellite-based CNS systems and the Global Navigation Satellite System (GNSS).

2.1.3 The Air Navigation Conference (AN-Conf./14) in its Recommendation 2.2/2 – *Interference to the Global Navigation Satellite System and Contingency Planning* reflects the need for effective spectrum management as a means of reducing the likelihood of interference, both intentional and unintentional. More specifically, said that;

States:

a) *ensure that effective global navigation satellite system radio frequency interference mitigation measures are implemented, based on measures developed by ICAO and industry, including the need to maintain a sufficient network of conventional navigation aids to ensure operational safety as well as sufficient airspace capacity during times of GNSS interference;*

and, that ICAO:

d) develop a standardized implementation package to assist and guide States in implementing effective global navigation satellite system radio frequency interference mitigation measures,

including optimization and rationalization of conventional navigation aids, commensurate with their local conditions, to ensure continuity in the provision of air navigation services;

e) develop guidance on civil-military coordination in relation to harmful interference to global navigation satellite system(s) originated or detected by military authorities;

2.1.4 These recommendations are combined with the need for a robust regulatory framework to control spectrum allocation and use in order to protect GNSS frequencies. At the international level, the International Telecommunication Union (ITU) establishes this framework through its Radio Regulations. At the national level, this task is the responsibility of the radio spectrum regulatory authorities of each State. In addition, the Radio Regulations (RR) annexed to the ITU constitution and the International Telecommunication Convention. With regard to the protection of frequencies, Article S4 of the RR in its Section I (General Provisions) states, in paragraph S4.10 that: *"Member States recognize that the safety aspects of the radionavigation service and other security services require special measures to ensure that they are free from harmful interference; it is therefore necessary to take this factor into account in the allocation and use of frequencies".*

2.1.5 The actions recommended by ICAO refer to the aeronautical authorities coordinating with the national regulatory authority in telecommunications matters, with a view to arbitrating preventive and corrective measures that include the resolution of cases of interference, through the detection of interference, locating the source and adopting the appropriate measures to resolve the interference.

2.1.6 In response to the high-level recommendations and in support of ICAO's aeronautical spectrum protection policies, at the regional level the NACC Ad-hoc Group on Regional Aeronautical Frequency Management and the SAM/IG Interop WG periodically develop technical notes related to interference cases.

2.2 Information and references available

2.2.1 A topic recommended by ICAO is the identification of cases of interference, for that you can count on information portals that collect reports, these are;

2.2.2 The IATA Global Navigation Satellite System GNSS Radio Frequency Interference Safety Risk Assessment (September 2024 edition) presents data taken from the Global Aviation Data Management (GADM) program.

2.2.3 The GPSJAM https://gpsjam.org/ website developed by John Wiseman in July 2022 represents on a daily map the GPS interference reported by aircraft, taking as a source the data provided by ADS-B Exchange, although it is not an official source but can be taken as an open access reference to observe current cases and to be able to make an analysis of the evolution in the areas of interest.

2.2.4 Avionics systems have evolved because, although first-generation GNSS systems use a single frequency band common to GPS and GLONASS and because of this, the probability of unintentional interference is higher and it is more susceptible to deliberate or intentional interference. SARPS provisions for multi-frequency GNSS equipment have already been defined, which will reduce the likelihood of unintentional interference and make intentional interference more difficult. This point is relevant since preventive and corrective measures should address both on-board equipment, the contingency infrastructure of conventional radio aids, the regulatory framework, and the control of possible sources of interference in the aeronautical field.

2.2.5 The need to maintain the conventional radio aid network as a contingency is developed in relevant planning documents, in addition to the aforementioned resolutions and recommendations. A very representative study was carried out within the framework of GREPECAS (PROJECT A2 program – AIR NAVIGATION SYSTEMS IN SUPPORT OF THE PBN) with the DME/DME Coverage Study for RNAV 5 presented and reviewed at Meetings SAM/IG/7 (May 2011) and SAM/IG/8 (October 2011). In view of

the evolution of the satellite navigation-based route network, consideration may be given to analysing the updating and expansion of the study. On this last point, it is worth mentioning the DEMETER tool of EUROCONTROL, which can also be evaluated for its application to the study.

2.3 Case of detection and resolution of GNSS interference at Aeroparque Metropolitano Jorge Newbery at Buenos Aires City (SABE/AER)

2.3.1 **Appendix A** of this note presents a case of detection and resolution of GNSS interference in Aeroparque produced in 2018. This case was initiated from notifications received by the Aeronautical Authority for failures in the avionics systems of different aircraft located on the platform. Although this event was recorded in 2018, the case is presented because it is considered a significant example due to the diversity and dispersion of interfering sources.

2.3.2 The corrective actions aimed at mitigating the degradation in operational safety caused by interference in GNSS signals that consequently affected procedures based on satellite navigation, were carried out at the Jorge Newbery Airport in a coordinated work that integrated the aeronautical authority, the national telecommunications authority, airlines, and airport operators and that as a result of the results obtained, Proposals were identified to develop a program of preventive actions at airports nationwide that operate with procedures based on satellite navigation, articulating this program with other programs of actions developed by the Aeronautical Authority for the regularization of telecommunications in the aeronautical field.

3 Conclusion

3.1.1 As a conclusion of the above, in line with the provisions of Recommendation 2.2/2 of the 14th Air Navigation Conference, the need to continue with the studies of GNSS interference cases is identified, in order to detect and correct situations of interference caused by external sources in the different phases of flight. and determine preventive actions to avoid future situations of interference that could be caused by various external sources. The proposal to consolidate a guidance guide that compiles the recommended preventive measures as well as the corrective actions applied is being considered, in order to provide the States with reference material with the particularities of the Region.

4 Suggested actions

1. The meeting is invited to:

   a) Take note of the information provided in this study note;

   b) To request that consideration be given to the development of guidance material at the regional level that compiles and keeps up to date the recommended preventive measures and corrective actions applied, with a view to presenting them as a frame of reference for States; and

   c) Suggest any other action that is considered necessary to contribute to continuous improvement.

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APPENDIX A

DETECTION AND RESOLUTION OF GNSS INTERFERENCE AT JORGE NEWBERY METROPOLITAN AIRPORT IN THE CITY OF BUENOS AIRES (SABE/AER)

Introduction

This document describes the situation that affected the normal operation of the GNSS receivers on board different aircraft at the time of their parking and movement on the apron that manifested themselves in malfunction/alarm of the on-board indicators, temporarily or permanently, during the complete operation from the apron parking. As well as the actions taken by the aeronautical authority for its solution and the recommendations for preventive and corrective actions.

Since this case of reports of signal loss in aircraft GPS receivers presumably caused by interference, was the first recorded in the aeronautical authority, it was considered useful to describe the situation of interference caused by external sources, present in the airport environment, on the on-board equipment and the possible problems that could arise from causes intrinsic to said system. Although it is not a current case since it was registered in 2018, it is considered a representative example due to the dispersion and diversity of the interference situations detected and their resolution.

Development. Reports of equipment failures in Aeroparque and resolution of external interference

Based on the notifications of repeated failures observed in the equipment on board aircraft located on SABE platforms presented by the airlines, the aeronautical authority National Civil Aviation Administration (ANAC) began research and analysis actions aimed at correcting this affectation in the GNSS signals, developing a comprehensive program that involved articulated work between the aeronautical authority, national aeronautical and regulatory organizations.

Affected equipment

According to the cases presented, the affected onboard equipment corresponded to aircraft from the BOEING 737-700/800/NG and EMBRAER 190 fleets. The on-board GNSS equipment (MMR) is from different manufacturers (HONEYWELL and ROCKWELL COLLINS) with CANADIAN MARCONI brand antennas. Failures were recorded in equipment 1 and 2 separately and simultaneously, which consisted of the loss of satellite signal (zero satellite availability) and the presentation of error messages.

Airport environment

Although the factors that affect GNSS-based navigation can be manifested in the different phases of flight, this analysis is particular while the aircraft is at the airport, where there is a great diversity of facilities that emit electromagnetic radiation with a much higher signal level than that received at the entrance of the GNSS receiver. Among these installations are the following fixed and mobile radio stations operating in different frequency bands:

- Mobile cellular telephony: operate in different frequency bands, 700 MHz, 800 MHz, 1900 MHz, 2100 MHz
- Base, repeater and mobile stations: VHF, UHF
- Fixed stations, point-to-point and point-to-multipoint radio links (internet access). VHF, UHF, MICROWAVE

- VSAT satellite stations: C-band, Ku
- Other sources of unintentional emissions such as: Engines, Vehicle trackers, Engine ignitions, Luminaire drivers, etc.

Although these systems and equipment do not operate on the frequencies assigned to GNSS, their non-essential emissions, whether by harmonics, spurious or intermodulation products, can overlap and affect the L1 channel (central value of 1575.42 MHz), and also that the signal level generated by the interfering sources is much higher than the reception threshold of the on-board equipment.

On the other hand, the airport infrastructure and its associated operations is a favourable environment for the generation of multipaths and blockages by shielding, due to the environment of buildings, parking lots, presence of movable structures, movements of aircraft and service vehicles.

In the particular case of Aeroparque Jorge Newbery, it presents the indicated characteristics of the presence of active sources of harmful radio interference and infrastructure and operations, which, as detailed below, configured the scope in which the cases of external interference that affected the operation of GNSS receivers on board aircraft located in the aforementioned maneuvering area occurred.

Technical checks carried out to detect and locate interference.

The affected companies presented the reported cases of GPS signal loss, indicating the type of aircraft, number of cases, dates, times and places of the events (parking positions of the commercial platform), providing the complete technical study that includes statistics, analysis of cases carried out by the maintenance areas of the companies themselves as well as opinions and recommendations of the manufacturers of the aircraft and equipment.

1. Evaluation, request for intervention to the national telecommunications authority and initial coordination:
   As a first step, the National Directorate of Air Navigation Inspection (DNINA) of the ANAC analyzed the reports provided and made consultations, in particular with the maintenance areas and responses of manufacturers, who stated that the failures may be due to factors external to the aircraft, recommending contacts with the airport authorities and technical verifications on the radio frequency spectrum to verify possible interferences. Once they had learned about the equipment, the failures detected, the phase of operation, the place and times in which it occurs most frequently, the background information on the permits corresponding to the radio stations located at the airport was collected, background information on similar cases reported was sought, and contacts were initiated with the national telecommunications authority – the National Communications Agency – (ENACOM).
   Meetings were held with ENACOM to provide more technical information, in order to be able to properly select the instruments and the modality for the technical verifications and with the airlines and airport managers to coordinate the start and require collaboration in the technical checks.

2. Technical checks:
   The first technical checks were carried out at the airport with ENACOM personnel, airline technicians and ANAC inspectors with the assistance of those responsible for the aforementioned airport. These technical checks were carried out with the ENACOM mobile unit and portable measuring instruments, in all positions of the commercial platform and on the general aviation platform, detailing below a summary of the activities that lasted approximately four months.

- Measurements with ENACOM vehicle and portable equipment – spectrum analyzer and directional antenna to analyze the GNSS frequency band (center frequency L1 and + - 10 MHz)
- Full commercial platform tour (sleeve and remote) performing measurements in parking positions, military platform, industrial platform. Complete tour by pre-boarding, PB, national arrivals and airport terrace.
- Detection of noise and non-essential emissions in the L1 band originating in a network composed of base stations operating in the UHF (460 MHz) MHz band and vehicle equipment that provides airport services, moving through all sectors of the airport. The necessary technical adjustments were required to correct the emissions
- Detection of strong level harmonics in the L1 band produced by a satellite tracking device in the vehicle, removing the device. then tests were carried out in the vicinity of aircraft without registering failures.
- Consultations with the crews of flights arriving by GPS news.
- Verification of satellite coverage. Identification of abandoned radiating systems and request for removal.
- Identification of cellular telephony installations, detection of noise and non-essential emissions in the frequency spectrums between 1511-1545 MHz and 1545-1575 MHz originating from cellular telephony panels installed on the terminal terrace. The measurements were repeated in the presence of technical personnel from the cell phone companies, determining that the non-essential emissions were generated by intermodulation of signals in the radiating base radio systems of two different companies, resulting in mixed interference. The characteristics of the base stations were 2G and 3G cellular telephony in the 1900 MHz band and LTE (4G) in the 2100 MHz band and 4G cellular telephony base LTE 700 MHz, 2100 MHz, 2G, 3G and GSM 850 MHz and 3G in 1900 MHz. Adjustments and replacements were made to correct non-essential emissions.
- Additionally, interferences were found in the aeronautical VHF band that affected the on-board equipment parked on the platform and that, from the checks carried out, it emerged as a result that they were the product of the drivers of the LED platform luminaires.
- Once the adjustments have been made and a reasonable time has been given, a new technical verification was carried out and because no new reports of interference have been received on the frequency of 1575.420 MHz and that the L Band of the GNSS (Global Navigation Satellite System) Signal operates normally, the technical verification stage is completed.

3. Presentation of the results

As a result of the technical checks carried out by technical personnel, various sources that generate interference conditions in the GNSS band produced by different equipment and radio systems located in various sectors of the Jorge Newbery Airport were detected, located and identified.

Conclusions and Recommendations

After the verification actions carried out jointly by the aeronautical and telecommunications authorities for the detection of interference, and the corrective actions carried out from the location of the interfering sources, the problems of failures reported by the aircraft in the maneuvering areas of the Jorge Newbery Airport ceased.

In this case, the airport environment and the origin of the interfering sources is similar to other case studies presented and addressed at an international level on interference to the GNSS system by external sources. Consequently, the measures taken to strengthen the control of radiation sources at an airport are also

applicable, so as to be able to have reliable and up-to-date identification and records of the radio systems installed and operational at an airport; since at the Jorge Newbery Airport there were cases of radio equipment that does not have the corresponding permits established by regulation, or that the equipment operates outside the authorized parameters. These issues are critical in cases of mobile stations that travel at the airport and in high-power stations, such as mobile phone radio bases.
The following recommended actions (identified from this case) can be integrated into a GNSS interference detection, assessment, mitigation, and prevention program.

Recommended actions:

- Maintain the identification and control of the radio installations at an airport and, in the event of disruption to aeronautical services, those responsible for the facilities can be detected more quickly in order to make the necessary technical adjustments. Greater application of control for mobile phone stations including periodic requirements for measurements and other technical evaluations, in consideration of proximity in the operating band and high radiated power.
- Coordinate intervention for periodic evaluations of a preventive nature, being able to consider operational safety reports and airline reports as a basis for the selection of airports.
- Evaluation of the use of DME-based navigation as an alternative and as part of a mitigation strategy in the event of interruption or degradation of GNSS signals in all phases of flight.
- Review and update of current regulations.
- Disseminate these findings to air operators, local authorities of the affected aerodrome. Extend these conclusions as awareness-raising measures to the aeronautical community and exchange the results and applied research methodology in international forums.

— END —