International Civil Aviation Organization

Twenty Eighth Meeting of the Communications/ Navigation and Surveillance Sub-group (CNS SG/28) of APANPIRG

Bangkok, Thailand, 01-05 July 2024

Agenda Item 6: Navigation

6.3 GNSS Interference and Mitigating Measures

ICAO RECOMMENDATIONS AND GUIDANCE ON GNSS VULNERABILITY

(Presented by the Secretariat)

SUMMARY

This paper presents an overview of ICAO's Recommendations and Guidance on Global Navigation Satellite System (GNSS) vulnerability, including the Resolution COM5/5 (WRC-23), ongoing work in NSP and regional efforts in APAC.

1. INTRODUCTION

1.1 The Global Navigation Satellite System (GNSS) plays as a technical enabler supporting improved services that meet the objectives outlined in the Global Air Navigation Plan (GANP) towards the achievement of the performance ambitions.

1.2 GNSS supports positioning, navigation and timing (PNT) applications. GNSS is already the foundation of performance-based navigation (PBN), automatic dependent surveillance – broadcast (ADS-B) and automatic dependent surveillance - contract (ADS-C). GNSS also provides a common time reference used to synchronize systems, avionics, communication networks and operations, and supports a wide range of non-aviation applications.

1.3 GNSS signals from satellites are very weak at the receiver antenna, so are vulnerable to interference. Current GNSS approvals in civil aviation use a single frequency band, this makes it easier to intentionally deny GNSS services by jamming GNSS signals and it also makes unintentional interference more likely to deny GNSS service.

1.4 GNSS typically serves more aircraft simultaneously and the interference may affect wider geographic areas than the services provided by conventional aids which can also be disrupted by interference.

1.5 The civil aviation community has been continuously working on mitigation guidelines to address GNSS vulnerability.

2. DISCUSSION

ANConf/11 and ANConf/12

2.1 In 2003, the 11th Air Navigation Conference (ANConf/11) developed *Recommendation 6/2* to States, based on GNSS vulnerability studies conducted by the GNSS Panel, the predecessor of Navigation Systems Panel (NSP), and accompanied by a detailed Appendix on mitigation methods. The text of *Recommendation 6/2* is provided in **Attachment A** to this paper.

2.2 In 2012, ANConf/12 developed *Recommendation 6/8* to States, which largely reiterates the main points of ANConf/11 Recommendation 6/2. The text of *Recommendation 6/8* is also provided in **Attachment A** to this paper.

Electronic Bulletin on Interference to GNSS Signals

2.3 In 2011, the EB *2011/56* is published to describe potential sources and types (intentional or unintentional) of interference to GNSS and recalls the essential role that ICAO Member States have in ensuring protection of GNSS signals from interference. It also contains a list of documents that can be used as guidance for States in developing a regulatory framework. The text of this EB is provided in **Attachment B** to this paper.

Memorandum of Cooperation with the International Telecommunication Union (ITU)

2.4 In 2012, pursuant to ANConf/12 Recommendation 6/7 (which addressed various actions on ICAO to assist States in mitigating GNSS vulnerabilities), ICAO and the international telecommunication union (ITU) signed a Memorandum of Cooperation (MoC) for "providing a framework for advanced cooperation regarding the protection of the GNSS from harmful interference with a potential on aviation safety". The MoC delimits the respective fields of responsibility of the two agencies and defines a formal cooperation procedure. In practice, the main benefit of the MoC has been the development of constructive informal relations between the respective entities responsible for GNSS RFI matters within the two Secretariats, which have proved to be of significant help in facilitating investigation and analysis of some RFI cases.

ICAO NSP Liaison Statements to RTCA and EUROCAE on Increased Protection of GNSS Receivers

2.5 In 2014, following the issuance of EB 2011/56 (see 2.3 above), further investigation within NSP revealed that the problems associated with GNSS RFI were still far from being solved. Accordingly, liaison statements were sent by NSP to the relevant technical groups within RTCA and EUROCAE, describing the problem and encouraging those groups to include improved capabilities for resistance against interference (or, as a minimum, capabilities to detect the presence of interference) in their development of future GNSS avionics.

2.6 Replies were received from both groups in 2015. One group stressed the difficulty standardizing improved capabilities for the resistance to interference but expressed willingness to cooperate in defining a minimum detection capability, while pointing out that definition of the threat was a sensitive task. The other informed ICAO that it had updated its Terms of Reference to include the following item: "5. *New MOPS should address, to the extent practicable, the threats of intentional interference and spoofing.*".

2.7 Following the exchange, both RTCA and EUROCAE have recently published avionics minimum operation performance standards (MOPS) supporting enhanced resistance to interference (e.g. RTCA DO-384, *MOPS for GNSS Aided Inertial Systems*; EUROCAE ED-259A/RTCA DO-401, *MOPS for Dual-Frequency Multi-Constellation Satellite-Based Augmentation System Airborne Equipment*). However, the general introduction of compliant equipment is unlikely to take place in the short term.

GNSS Manual (DOC 9849)

2.8 In 2017, the third edition of the GNSS Manual was published, which significantly extended the coverage of RFI matters, by updating Chapter 5 (GNSS vulnerability) and Chapter 7 (Implementation of GNSS-based services, sections 7.12 (Anomaly reporting) and 7.13 (GNSS vulnerability: mitigating the impact on operators)).

2.9 Most importantly, it introduced a new **Appendix F** (GNSS Radio Frequency Interference Mitigation Plan), with over 20 pages of new material. The framework recommended to implement the mitigation plan includes a continuous three-step process, comprising threat monitoring, risk assessment and deployment of mitigation measures. Checklists of preventive and reactive measures aimed at mitigating the interference risk, as far as practicable, are also provided.

2.10 The 4th edition of the GNSS Manual was published in 2023, which introduced further updates.

40th Session of the Assembly / State Letter 2020/89 / ITU Circular Letter 488

2.11 During the 40th Session of the Assembly (2019), a number of papers called for actions to strengthen CNS systems resilience and mitigate interference to GNSS. The Assembly agreed with the proposals and recommended that the Council act with urgency on measures aimed at elimination of harmful interference.

2.12 As a follow-up, State letter 2020/89 conveyed to States the content of the Assembly agreement, and in particular the elements that were relevant for action by States.

2.13 Consistently with the Assembly agreement, SL 2020/89 letter also stresses the importance of applying the GNSS radio frequency interference mitigation plan outlined in the GNSS Manual (Doc 9849).

2.14 The elements of SL 2020/89 reported above were also quoted in ITU Circular Letter CR/488 (2022), in which the ITU Radiocommunication Bureau noted with great concern the increasing number and range of impact of harmful interference on safety-of-life radiocommunication services used for the navigation of aircraft, and reported on related decisions by the ITU Radio Regulations Board (RRB). In the context of the ITU letter, those elements appear as “additional measures to address this critical issue”, in conjunction with the applicable provisions of the ITU’s own legal instruments invoked by the RRB in its decisions.

2.15 ICAO APAC Office issued State Letter T 8/5.10: AP099/22 (CNS) on 21 July 2022 with Subject: *Prevention of harmful interference to Radio Navigation Satellite Service Receivers in the 1559 – 1610 MHz frequency band* to circulate the ITU RB Circular Letter CR/488 and the ICAO State Letter Ref.: AN 7/5-20/89. The ICAO APAC State Letter is provided in **Attachment C** to this paper.

41st Session of the Assembly

2.16 In 2022, just as at the 40th Session of the Assembly, a number of papers at the 41st Session of the Assembly called for actions to strengthen CNS systems resilience and mitigate interference to GNSS. In particular, one paper (A41-WP/97) presented/co-sponsored by over 100 States provided information on the growing number of occurrences of GNSS RFI events, notwithstanding the actions agreed by the 40th Session of the Assembly and reiterated in State letter 2020/89. Accordingly, the paper called for further action to mitigate GNSS and strengthen CNS system resilience. The Assembly agreed with the proposals and recommended that the Council act with urgency on measures aimed at elimination of harmful interference.

2.17 The Assembly further adopted the proposed new **Appendix C** to **Assembly Resolution 41-8** (reproduced in **Attachment D** to this paper). The new Appendix effectively constitutes the latest and most authoritative statement of ICAO policy on GNSS (and more generally CNS systems) resilience.

Amendment 93 to Annex 10, Volume I

2.18 Amendment 93 to Annex 10, Volume I (applicable from 2 November 2023) introduces dual-frequency, multi-constellation (DFMC) GNSS. DFMC GNSS, by introducing additional frequencies of GNSS operation and additional GNSS constellations, enhances resistance to GNSS RFI insofar as interference, both intentional and unintentional, targeting only one GNSS frequency or one constellation, can potentially be mitigated by the use of alternative GNSS frequencies and/or constellation. Avionics standards (MOPS) supporting DFMC GNSS have been published (EUROCAE ED-259A/RTCA DO-401, mentioned in paragraph 2.7 above) or are under development. However, as mentioned in paragraph 2.7 above, general introduction of compliant equipment is unlikely to take place in the short term.

Ongoing NSP Work

2.19 Ongoing NSP work related to GNSS RFI mitigation is driven mainly by Job cards NSP.003 (GNSS Evolution – SBAS); NSP.006 (GNSS RFI) and NSP.008 (Alternative Position Navigation and Timing (APNT)).

2.20 Under Job card NSP.003, an additional optional authentication feature in the SBAS SARPs is being developed. The purpose of the feature is to prevent spoofing of SBAS signals[1].

2.21 Under Job card NSP.006, planned deliverables include an update of the existing GNSS RFI-related guidance in Doc 9849 (see 2.8, 2.9, 2.10) and Doc 8071, and a concept of operation for next generation equipment functions to improve navigation service robustness in the presence of RFI to GNSS.

2.22 A significant recent development triggered by the NSP work under this Job card was the approval by the ITU World Radiocommunications Conference (2023) (WRC-23) of a **Resolution**

[1] An optional authentication feature for GBAS signals was introduced in Annex 10, Volume I in 2009 (Amendment 86).

on prevention and mitigation of harmful interference to GNSS (Resolution COM 5/5 (WRC-2023))[2] (reproduced in **Attachment E** to this paper).

2.23 Under Job card NSP.008, planned deliverables include guidance as appropriate to maintain safe and efficient operations in case of GNSS outages (to be coordinated with other panels[3]); a report on APNT, including consideration of the feasibility of a long-term replacement or enhancement of DME as the main APNT system; and amendments to DME and other provisions in Annex 10, Volume I, to optimize APNT functions while preparing for an efficient transition.

APANPIRG Conclusions and Actions

2.24 With the introduction of GNSS-based operations in 1990s, Asia & Pacific Regions have been discussing various challenges and resolving measures for GNSS interference, some APANPIRG Conclusions were developed and adopted, including **APANPIRG Conclusion 8/43** - GNSS Frequency Based Interference (1997), **Conclusion 9/32** - GNSS Frequency Protection (1998), **Conclusion 22/28** - Protection of aviation utility of GNSS (2011), **Conclusion APANPIRG/27/36**: Protection of GNSS signal against jamming (2016).

2.25 Promoting awareness on GNSS RFI was identified as a key action in dealing with CNS Challenges in 2024 by the APANPIRG/34, the meeting urged States and airspace users (through IATA) to report GNSS occurrences to ICAO APAC Office using the reporting templates which would be circulated in a State Letter. With reference to the 4th Edition of ICAO Doc 9849 GNSS Manual, the Eighth Meeting of Spectrum Review Working Group (SRWG/8) proposed and adopted the example forms for GNSS Interference Reporting in APAC, which was circulated by State Letter **Ref.:** T 8/5.10 – AP052/24(CNS) on 23 April 2024, and is provided in **Attachment F** to this paper. IATA presented its Analysis on GNSS radio frequency interference in APAC region through WP/12 of SRWG/8 meeting in March 2024.

2.26 On 30 April 2024, ICAO Secretary General signed a State Letter Ref.:E 3/5-24/54 **Subject**: Aviation safety concerns regarding interference to the Global Navigation Satellite System (GNSS), which circulated the outcome of ICAO EUR/MID Radio Navigation Symposium held from 6 to 8 February 2024 in Antalya, Turkey. The outcome of this symposium is the attached list of recommendations regarding Stakeholders' continued efforts towards ensuring safe, reliable, and resilient air navigation. The State Letter is provided in **Attachment G** to this paper.

[2] The process that led to the approval of the Resolution started with the agreement reached by NSP/7 that an ITU WRC resolution on GNSS RFI would be highly desirable. In this connection, the meeting also agreed that the Frequency Spectrum Management Panel (FSMP) should also be approached to ensure that the formal ICAO position for WRC-23 recognize that a WRC-23 ITU resolution was desirable. NSP/7 also encouraged aviation stakeholders to coordinate this matter with State radio regulatory authorities. Although FSMP could not agree to modify the ICAO position, it created a correspondence group (CG) on the issue. The purpose of the CG would be to help collect the relevant information that may be helpful for national Administrations to submit to the relevant ITU technical bodies in preparation for WRC-23. The output of the CG was submitted to ITU Working Party 4C and to the European regional body responsible for the development of the European proposals for ITU WRC-23. Triggered, inter alia, by this material, the European proposals for ITU WRC-23 included a draft Resolution on prevention and mitigation of harmful interference to GNSS, which was eventually adopted by the WRC with some modifications as the above mentioned Resolution COM5/5 (WRC-23).

[3] In particular, coordination with FLTOPSP has been initiated recently.

3. ACTION BY THE MEETING

3.1 The meeting is invited to:

a) note the information contained in this paper;
b) share above mentioned information with all stakeholders;
c) reiterate the importance of surveillance (independent of GNSS source) and air-ground communication for operations, and GNSS-independent time source for synchronization, in case of GNSS outage;
d) consider the required functionality for ATM automation in supporting controllers to deal with scenarios concerned;
e) approach APAC Office for any difficulties in using the example forms for GNSS Interference Reporting in APAC, which was circulated by State Letter Ref.: T 8/5.10 – AP052/24(CNS);
f) encourage airlines to support the IATA Flight Data Exchange (FDX) mechanism to make the complete FDX Analysis on GNSS RFI in APAC;
g) encourage States/Administrations to share experience on implementing and maintaining necessary minimum operational networks (MON); and
h) take necessary actions to address this critical issue as appropriate.

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Recommendation 6/2 of the 11th Air Navigation Conference (ANConf/11) in 2003

Recommendation 6/2 — Guidelines on mitigation of GNSS vulnerabilities

That States in their planning and introduction of GNSS services:

a) assess the likelihood and effects of GNSS vulnerabilities in their airspace and utilize, as necessary, the mitigation methods as outlined in the guidelines contained in Appendix A to the report on Agenda Item 6;

b) provide effective spectrum management and protection of GNSS frequencies to reduce the possibility of unintentional interference;

c) take full advantage of on-board mitigation techniques, particularly inertial navigation;

d) where determined that terrestrial navigation aids need to be retained as part of an evolutionary transition to GNSS, give priority to retention of DME in support of INS/DME or DME/DME RNAV for en-route and terminal operations, and of ILS or MLS in support of precision approach operations at selected runways; and

e) take full advantage of the future contribution of new GNSS signals and constellations in the reduction of GNSS failures and vulnerabilities.

Recommendation 6/8 of the 12TH Air Navigation Conference (ANConf/12) in 2012

Recommendation 6/8 – Planning for mitigation of global navigation satellite system vulnerabilities

That States:

a) assess the likelihood and effects of global navigation satellite system vulnerabilities in their airspace and apply, as necessary, recognized and available mitigation methods;

b) provide effective spectrum management and protection of global navigation satellite system (GNSS) frequencies to reduce the likelihood of unintentional interference or degradation of GNSS performance;

c) report to ICAO cases of harmful interference to global navigation satellite system that may have an impact on international civil aviation operations;

d) develop and enforce a strong regulatory framework governing the use of global navigation satellite system repeaters, pseudolites, spoofers and jammers;

e) allow for realization of the full advantages of on-board mitigation techniques, particularly inertial navigation systems; and

f) where it is determined that terrestrial aids are needed as part of a mitigation strategy, give priority to retention of distance measuring equipment (DME) in support of inertial navigation system (INS)/DME or DME/DME area navigation, and of instrument landing system at selected runways.

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International Civil Aviation Organization

ELECTRONIC BULLETIN

For information only

EB 2011/56
AN 7/5

21 November 2011

INTERFERENCE TO GLOBAL NAVIGATION SATELLITE SYSTEM (GNSS) SIGNALS

1. Aviation operations increasingly rely on the global navigation satellite system (GNSS) to improve navigation performance and to support air traffic control surveillance functions.

2. However, the full benefits of GNSS can only be achieved if GNSS signals are adequately protected from electromagnetic interference which can cause loss or degradation of GNSS services.

3. Potential sources of interference to GNSS include both systems operating within the same frequency bands as GNSS and systems operating outside those bands. Interference can be intentional ("jamming") or unintentional.

4. ICAO Member States have an essential role in ensuring protection of GNSS signals from interference. This can be achieved through cooperation of national aviation and telecommunication authorities in the introduction and enforcement of appropriate regulations controlling the use of the radio spectrum.

5. Attachment A briefly describes some sources of interference to GNSS and discusses regulatory means available to States to deal with them. Attachment B contains a list of documents that can be used as guidance for States in developing a regulatory framework.

Enclosures:

A — Sources of interference to GNSS
B — References

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ATTACHMENT A to EB 2011/56

SOURCES OF INTERFERENCE TO THE GLOBAL NAVIGATION SATELLITE SYSTEM (GNSS)

1. INTERFERENCE TO GNSS CAUSED BY SYSTEMS TRANSMITTING IN GNSS FREQUENCY BANDS

1.1 GNSS repeaters and pseudolites

1.1.1 Certain non-aeronautical systems transmit radio signals intended to supplement GNSS coverage in areas where GNSS signals cannot be readily received (e.g. inside buildings). These systems include GNSS repeaters and pseudolites.

1.1.2 GNSS repeaters (also known as "re-radiators") are systems that amplify existing GNSS signals and re-radiate them in real-time. Pseudolites are ground-based systems that generate ranging signals similar to those transmitted by GNSS satellites.

1.1.3 When these systems do not operate under appropriate conditions, harmful interference may be caused to the reception of the original GNSS signals by aircraft and other aeronautical systems (such as the reference receivers used in augmentation systems). This may disrupt a wide range of GNSS applications.

1.1.4 To prevent this disruption, a State needs to create a regulatory framework for the sale, ownership and operation of these systems. The framework must include regulations to ensure that use of the systems be permitted only where they have a legitimate application and their operation is not harmful to existing primary users of GNSS-based services. Additional measures may be necessary when repeaters and pseudolites are used on or in the vicinity of airports (e.g. in hangars, for testing/maintenance purposes).

1.1.5 Attachment B contains a list of documents that can be used as guidance for States developing a regulatory framework. They include interference analyses and examples of regulations currently in force in Europe and the United States.

1.2 GNSS jammers

1.2.1 GNSS jammers are devices which intentionally generate harmful interference to GNSS signals to impair or deny their reception. They may be employed for various reasons, typically with the intent of disabling devices that record and/or relay GNSS position information (e.g. for tracking or fee collection purposes). However, the interference they generate can potentially affect all users of GNSS, not only the intended targets of the jamming. Thus, they may have an impact far greater than intended by their operator.

1.2.2 Usage of GNSS jammers may proliferate further if GNSS-based fee collection or tracking services are not adequately designed, e.g. if the simple use of a jamming device enables the avoidance of the charge or tracking.

1.2.3 To prevent degradation of GNSS services due to GNSS jammers, States should implement and enforce policies and regulations that forbid the sale, export, purchase, ownership and use of GNSS jammers, and they should prohibit all actions that lead to an interruption of GNSS signals[1]. Adequate means of enforcement of such policies and regulations require the availability of GNSS signal monitoring capabilities. Furthermore, GNSS-based services should be designed in such a way that simple jamming does not result in denial of the service.

2. INTERFERENCE TO GNSS CAUSED BY SYSTEMS TRANSMITTING OUTSIDE THE GNSS FREQUENCY BANDS

2.1 In addition to the threats described above, systems operating outside the GNSS frequency bands that are not properly designed or are inappropriately regulated and operated may interfere with GNSS.

2.2 GNSS frequencies are protected by international agreements (ICAO *Convention on International Civil Aviation* and ITU Radio Regulations), and enable aviation services that have significant economical and societal benefits. However, there is also significant demand for electromagnetic spectrum for new applications, such as mobile phone and broadband data services, which may compromise spectrum compatibility. States should require that any such application will not interfere with GNSS signals through execution of adequate spectrum management practices.

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[1] In some States, military authorities test their equipment by occasionally transmitting jamming signals that deny service in a specific area. This activity should be coordinated with State spectrum authorities and air navigation service providers to enable them to determine the airspace affected, advise aircraft operators and develop any required contingency procedures.

ATTACHMENT B to EB 2011/56

REFERENCES

ECC Report 129: "Technical and operational provisions required for the use of GNSS repeaters", Dublin, January 2009 (available at: http://www.ecodocdb.dk/, see under "ECC Reports")

ECC Report 145: "Regulatory framework for Global Navigation Satellite System (GNSS) repeaters", St. Petersburg, May 2010 (available at: http://www.ecodocdb.dk/, see under "ECC Reports")

ECC Recommendation (10)02, "A framework for authorization regime of Global Navigation Satellite System (GNSS) repeaters" (available at: http://www.ecodocdb.dk/, see under "ECC Recommendations")

United States National Telecommunications and Information Administration (NTIA) Manual of Regulations and Procedures for Federal Radio Frequency Management (Redbook), sections 8.3.28 – 8.3.30 (available at: http://www.ntia.doc.gov/page/2011/manual-regulations-and-procedures-federal-radio-frequency-management-redbook)

Note.— The relevant sections of the NTIA Redbook only apply to the United States Federal Government users. Use of repeaters by non-government users is prohibited in the United States.

— END —

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Ref.: T 8/5.10 : AP099/22 (CNS) 21 July 2022

Subject: Prevention of harmful interference to Radio Navigation Satellite Service Receivers in the 1559 – 1610 MHz frequency band

Action Required:

1) Note the information contained in the ITU RB Circular Letter CR/488;
2) Note the information contained in the ICAO State Letter Ref.: AN 7/5-20/89; and
3) Take actions as appropriate.

Dear Sir/Madam,

I wish to draw your attention to the prevention of harmful interference to Radio Navigation Satellite Service Receivers in the 1559 – 1610 MHz frequency band.

The Radiocommunication Bureau (RB) of International Telecommunication Union (ITU) has been informed of a significant number of cases of harmful interference to the radio navigation satellite service (RNSS) in the 1559 – 1610 MHz frequency band affecting receivers onboard aircrafts, causing degradation or total loss of the service for passenger, cargo and humanitarian flights, and leading to misleading information provided by RNSS receivers to pilots in some cases. Based on in-flight monitoring of air transport category aircraft global navigation satellite system (GNSS) receivers by one major aircraft manufacturer, 10843 radio-frequency interference events were detected globally in 2021. The majority of these events occurred in the Middle East region, but several events were also detected in the European, North American, and Asian regions.

With great concern about the increasing number and range of impact of such harmful interference on safety-of-life radiocommunication services used for the navigation of aircraft, the ITU RB issued the Circular Letter CR/488 with the subject of *Prevention of harmful interference to Radio Navigation Satellite Service Receivers in the 1559 – 1610 MHz frequency band* on 8th July 2022 which is provided in **Attachment A**.

The Circular Letter also highlighted the recommendations and measures on prevention and mitigation of harmful interference to GNSS agreed by the International Civil Aviation Organization (ICAO) at 40th Assembly in October 2019 and disseminated by ICAO State Letter Ref.: AN 7/5-20/89 dated 28th August 2020 with Subject of *Strengthening of communications, navigation, and surveillance (CNS) systems resilience and mitigation of interference to global navigation satellite system (GNSS)* provided in **Attachment B**.

Your State/Administration is strongly encouraged to share above mentioned information with operators, service providers and all stakeholders, sensitize the national radio regulatory Authority to the risk encountered by the civil aviation, and take actions to address this critical issue as appropriate.

Accept, Sir/Madam, the assurances of my highest consideration.

Tao Ma
Regional Director

Enclosures:
Attachment A – ITU RB Circular Letter CR/488
Attachment B – ICAO State Letter Ref.: AN 7/5-20/89

Radiocommunication Bureau (BR)

Circular Letter
CR/488

8 July 2022

To Administrations of Member States of the ITU

Subject: **Prevention of harmful interference to Radio Navigation Satellite Service Receivers in the 1559 – 1610 MHz frequency band**

Following its initial report to the 2019 World Radiocommunication Conference, the Radiocommunication Bureau has been informed of a significant number of cases of harmful interference to the radionavigation-satellite service (RNSS) in the 1 559 – 1 610 MHz frequency band affecting receivers onboard aircrafts and causing degradation or total loss of the service for passenger, cargo and humanitarian flights. In some cases, this has also led to misleading information provided by RNSS receivers to pilots. Based on in-flight monitoring of air transport category aircraft GNSS receivers by one major aircraft manufacturer, 10 843 radio-frequency interference events were detected globally in 2021. The majority of these events occurred in the Middle East region, but several events were also detected in the European, North American and Asian regions.

The Bureau has noted with great concern the increasing number and range of impact of such harmful interference on safety-of-life radiocommunication services used for the navigation of aircraft (see No. **4.10**[1]). In accordance with RR No. **13.2**, the Bureau reported such cases to the Radio Regulations Board (RRB), together with its recommendations.

At its 89th meeting in March 2022, the ITU Radio Regulations Board (RRB) considered the situation and instructed the Bureau to issue a circular letter to the Member States to disseminate its decisions and other background information about the prevention of harmful interference to RNSS receivers.

Following this instruction, the Bureau has prepared the present circular letter. It summarizes the RRB's decisions on the issue, formulates recommendations concerning mitigation of harmful interference to the radionavigation-satellite service and provides the list of the relevant ITU-R reference documents.

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[1] "*Member States recognize that the safety aspects of radionavigation and other safety services require special measures to ensure their freedom from harmful interference; it is necessary therefore to take this factor into account in the assignment and use of frequencies.*"

The relevant decisions of the 89th RRB meeting

In accordance with No. 13.2, the Board decided to request Member States to ensure that their operating agencies complied with the applicable provisions of the ITU legal instruments, as emphasized below:

- "*All stations, whatever their purpose, must be established and operated in such a manner as not to cause harmful interference to the radio services or communications of other Member States or of recognized operating agencies, or of other duly authorized operating agencies which carry on a radio service, and which operate in accordance with the provisions of the Radio Regulations.*" (Article 45 of the ITU Constitution)

- "*to take the steps required to prevent the transmission or circulation of false or deceptive distress, urgency, safety or identification signals, and to collaborate in locating and identifying stations under their jurisdiction transmitting such signals.*" (Article 47 of the ITU Constitution)

- "*1 Member States retain their entire freedom with regard to military radio installations.*

2 Nevertheless, these installations must, so far as possible, observe statutory provisions relative to giving assistance in case of distress and to the measures to be taken to prevent harmful interference, and the provisions of the Administrative Regulations concerning the types of emission and the frequencies to be used, according to the nature of the service performed by such installations.

3 Moreover, when these installations take part in the service of public correspondence or other services governed by the Administrative Regulations, they must, in general, comply with the regulatory provisions for the conduct of such services." (Article 48 of the ITU Constitution)

- "*Recognizing that transmissions on distress and safety frequencies and frequencies used for the safety and regularity of flight (see Article 31 and Appendix 27) require absolute international protection and that the elimination of harmful interference to such transmissions is imperative, administrations undertake to act immediately when their attention is drawn to any such harmful interference.*" (RR No. **15.28**)

The Board further decided to request Member States to continue to exercise their utmost goodwill and mutual assistance in the application of the provisions of Article 45 of the Constitution and of Section VI of Article **15** of the Radio Regulations.

Recommendations on prevention and mitigation of harmful interference to RNSS

With respect to unnecessary transmissions, which represent one of the important sources of interference to RNSS, the Bureau would like to point out that the use of devices commonly referred as "GNSS jammers" or any other illegal interfering equipment, which may cause harmful interference to aircraft, are prohibited by provision No. **15.1** of the Radio Regulations:

> *15.1 § 1 All stations are forbidden to carry out unnecessary transmissions, or the transmission of superfluous signals, or the transmission of false or misleading signals, or the transmission of signals without identification (except as provided for in Article **19**).*

In addition, the administrations are encouraged to consider the following additional measures to address this critical issue:

a) reinforcing navigation systems resilience to interference;
b) increasing collaboration between radio regulatory and enforcement authorities;
c) reinforcing civil-military coordination to address interference risks associated with RNSS testing and conflict zones;
d) increasing coordination between aviation, military and radio-regulatory authorities;
e) retaining essential conventional navigation infrastructure for contingency support in case of RNSS outages, and developing mitigation techniques for loss of services.

The above measures were decided by the International Civil Aviation Organization (ICAO) at its 40th Assembly in October 2019 and disseminated by ICAO State Letter AN 7/5-20/89 dated 28 August 2020.

Relevant ITU-R reference documents

In order to get an overview of the usage and protection requirements of systems operating in the radionavigation-satellite service, administrations may consult the following ITU-R Recommendations and Reports:

- Recommendation ITU-R M.1787-4 – Description of systems and networks in the radionavigation-satellite service (space-to-Earth and space-to-space) and technical characteristics of transmitting space stations operating in the bands 1 164-1 215 MHz,1 215-1 300 MHz and 1 559-1 610 MHz
- Recommendation ITU-R M.1901-3 – Guidance on ITU-R Recommendations related to systems and networks in the radionavigation-satellite service operating in the frequency bands 1 164-1 215 MHz, 1 215-1 300 MHz, 1 559-1 610 MHz, 5 000-5 010 MHz and 5 010-5 030 MHz
- Recommendation ITU-R M.1903-1 – Characteristics and protection criteria for receiving earth stations in the radionavigation-satellite service (space-to-Earth) and receivers in the aeronautical radionavigation service operating in the band 1 559-1 610 MHz
- Report ITU-R M.2458-0 – Radionavigation-satellite service applications in the 1 164-1 215 MHz, 1 215-1 300 MHz and 1 559-1 610 MHz frequency bands

The Bureau thanks Administrations for disseminating this information among their different operating agencies to raise awareness of the situation and to remind them of their obligation to prevent any harmful interference in accordance with ITU's Legal Instruments.

Mario Maniewicz
Director

Distribution:

- Administrations of ITU Member States
- Members of the Radio Regulations Board

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Tel.: +1 514-954-8219 ext. 6717

Ref.: AN 7/5-20/89

28 August 2020

Subject: Strengthening of communications, navigation, and surveillance (CNS) systems resilience and mitigation of interference to global navigation satellite system (GNSS)

Action required: Note the criticality of the issue and the importance of action by States to address it by making use of the ICAO guidance provided in Doc 9849, *Global Navigation Satellite System (GNSS) Manual* and by taking any other measures as appropriate

Sir/Madam,

1. I have the honour to inform you that the Council, at the ninth meeting of its 220th Session on 22 June 2020, agreed with the proposal to bring to the attention of States the actions agreed by the 40th Session of the Assembly (24 September – 4 October 2019) with regard to communications, navigation, and surveillance (CNS) systems resilience and mitigation of harmful interference to global navigation satellite system (GNSS).

2. The agreed actions were pursuant to proposals contained in Assembly working papers A40-WP/82, A40-WP/352 and A40-WP/188, presented respectively by Finland on behalf of the EU and its Member States[1], by Saudi Arabia and jointly by the International Federation of Air Traffic Controllers' Associations (IFATCA), the International Federation of Air Line Pilots' Associations (IFALPA) and the International Air Transport Association (IATA). The papers identified issues related to the evolution of CNS systems and the associated threats and vulnerabilities, with particular regard to satellite-based CNS systems, such as GNSS. They highlighted, in particular, the impact from harmful interference to GNSS on the safety and efficiency of aircraft and ATM operations, and identified the need to strengthen the protection of GNSS signals from harmful interference and degradation of performance through actions by States and ICAO in coordination with industry.

[1] Austria, Belgium, Bulgaria, Croatia, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden and United Kingdom.

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3. The Assembly noted the essential commonality of purpose among the three papers and agreed with the proposals contained therein (*Assembly Fortieth Session, Technical Commission Report*, Doc 10137, A40-TE, 30.15 refers). The attachment to this letter compiles the proposals that are relevant for action by States. In summary, they include: reinforcing CNS system resilience to interference, preventing the use of illegal interfering devices, increasing collaboration with radio regulatory and enforcement authorities, reinforcing civil-military coordination to address interference risks associated with GNSS testing and conflict zones, increasing coordination between aviation and radio-regulatory authority and military, retaining essential conventional navigation infrastructure for contingency support in case of GNSS outages, and developing mitigation techniques for loss of services.

4. In particular, all three papers stress the importance of applying the GNSS radio frequency interference mitigation plan outlined in the ICAO *Global Navigation Satellite System (GNSS) Manual* (Doc 9849). The framework recommended to implement the mitigation plan includes a continuous three-step process, comprising threat monitoring, risk assessment and deployment of mitigation measures. Checklists of preventive and reactive measures aimed at mitigating the interference risk, as far as practicable, are also provided.

5. May I request that you note the criticality of the issue and the importance of action by States to address it by making use of the ICAO guidance provided in Doc 9849, and by taking any other measures, as appropriate.

Accept, Sir/Madam, the assurances of my highest consideration.

Fang Liu
Secretary General

Enclosure:

Actions agreed by the 40th Session of the Assembly to strengthen CNS systems resilience and mitigate interference to GNSS

ATTACHMENT to State letter AN 7/5-20/89

Actions agreed by the 40th Session of the Assembly
to strengthen CNS systems resilience and mitigate interference to GNSS

From *A40-WP/82,* States are urged to:

"1) transition from a CNS system-based concept towards secure CNS services, mainly based on a satellite-based infrastructure while addressing its resiliency to interference through independent minimum operational networks based on ground and/or airborne components;
2) apply necessary measures to avoid the commercialisation / proliferation and the use of illegal transmitters such as jammers which may impact satellite-based CNS systems;
3) ensure, considering that the use of radio frequency spectrum by aeronautical safety services requires special measures, close collaboration between aviation authorities, service providers, radio regulatory and spectrum enforcement authorities to ensure that this spectrum is free from harmful interference;
4) reinforce civil-military collaboration regarding global navigation satellite system (GNSS) testing and other activities, which may impact satellite-based CNS systems, with the air navigation services provider (ANSP) responsible for the affected airspace; and
5) consider, when assessing the interference risks associated with conflict zones, that the use of satellite-based CNS systems can potentially be impacted beyond that zone."

From *A40-WP/352,* States are urged to:

"1) assess the likelihood and effects of global navigation satellite system vulnerabilities in their airspace and apply, as necessary, ICAO mitigation methods;
2) provide effective spectrum management and protection of global navigation satellite systems (GNSS) frequencies to reduce the likelihood of unintentional interference or degradation of GNSS performance; and
3) cooperate for design, development and realization of Ground and on-board mitigation techniques of GNSS loss of service;"

From *A40-WP/188,* the Assembly is invited to:

"a) to implement appropriate mitigation measures as contained in the *Global Navigation Satellite System (GNSS) Manual* (Doc 9849) as a matter of high priority and to report progress and any difficulties to ICAO;
b) to recognize the unintended impact of harmful interference to civil flight operations and to exercise caution to the maximum extent possible to protect the safety of civil aircraft during military exercises and operations;
c) to establish and ensure appropriate frequency regulations are in place and maintained to protect allocated GNSS frequencies from harmful interference in line with ITU Radio Regulations;
d) to ensure that contingency procedures are established in coordination with air navigation service providers and airspace users and that essential conventional navigation infrastructure, such as Instrument Landing System (ILS), are retained when operationally beneficial; and
e) to support the multi-disciplinary development of alternative positioning, navigation and timing (APNT) strategy and solutions to complement the use of GNSS in aviation in coordination with ICAO and airspace users."

— END —

Assembly Resolutions in Force Relevant to GNSS RFI

(as of 7 October 2022)
Extracted from Doc 10184.

A41-8: Consolidated statement of continuing ICAO policies and practices related to a global air traffic management (ATM) system and communications, navigation, and surveillance/air traffic management (CNS/ATM) systems

*This resolution supersedes A35-15.

APPENDIX C
Ensuring the resilience of ICAO CNS/ATM systems and services

Whereas the CNS/ATM systems are evolving and so are the associated CNS threats and vulnerabilities;

Whereas the occurrences of interferences against satellite-based CNS systems and global navigation satellite system (GNSS), in particular, have significantly increased;

Whereas CNS resiliency to interference needs to be addressed at a global level with a holistic approach, ensuring an efficient and coordinated evolution between the infrastructure architecture, improved technological capabilities, civil and military operational procedures, radio regulatory authorities and civil-military coordination;

Recognizing that resiliency to interference needs to be improved by maximizing the integration of all suitable ground infrastructure, space infrastructure and airborne components in a complementary and cooperative manner to be as robust as possible to cases of satellite-based service disruption or environments where false or deceptive signals are present;

Recognizing that both the aircraft on-board and ground infrastructure complementing the satellite-based CNS systems need to be adapted to include, where appropriate, interference detection, mitigation and reporting functions to support the resolution of operationally encountered performance anomalies;

Believing that, combined with the use of the appropriate legal framework, such capabilities and measures will allow for the relevant authorities to act upon harmful interferences caused by the illegal operation of transmitters and avoid the proliferation and the use of such illegal transmitters and the misuse of test and maintenance equipment;

Believing that, with appropriate coordination and application of best practices, military and State authorities can conduct GNSS-related testing and other interventions using radio equipment as necessary and without causing an undue impact on civil aviation;

Believing that civil-military coordination should facilitate the sharing of relevant information with airspace users, especially when flying in the vicinity of a conflict zone; and

Acknowledging that loss of crew's situational awareness from malicious origin is classified as a cyber-security threat and cannot be tolerated in civil aviation; and that intentionally sending misleading signals to replace the accurate signal is a far more serious threat to flight safety than the loss of this signal.

The Assembly:

1. Encourages States to transition towards optimized, secure CNS systems based on complementary integration of suitable and independent aircraft capabilities, satellite- and ground-based infrastructure which maximize resiliency and robustness to any type of interference;

2. Encourages standardization bodies and industry to develop appropriate interference detection, mitigation and reporting capabilities for the aircraft on-board, satellite- and ground-based CNS system components, in order to ensure higher CNS resiliency, continuity of operations and prevent any cascading effects from the use of compromised position, velocity or time data;

3. Encourages States to ensure that sufficient terrestrial CNS capabilities remain available to ensure safe operations and complement aircraft-level integration of position, velocity and time with independent surveillance information;

4. Invites ICAO to develop high-level principles on how to integrate CNS ground, space and on-board systems and capabilities to obtain more resilient positioning and timing services;

5. Urges States to apply necessary measures to avoid the commercialization/proliferation and the use of illegal transmitters such as jammers and the misuse of test and maintenance equipment which may impact CNS systems;

6. Urges States to ensure close collaboration between aviation authorities, military authorities, service providers, radio regulatory and spectrum enforcement authorities to put in place any special measures required to ensure that spectrum used by all CNS systems, and GNSS in particular, is free from harmful interference;

7. Urges States to refrain from any form of jamming, or spoofing affecting civil aviation;

8. Urges States to coordinate and notify to the maximum extent possible in advance with the air navigation services provider (ANSP) responsible for the affected airspace in case of military or other State-authorized security or defence-related operations or training, potentially causing any form of jamming, or spoofing affecting civil aviation; and

9. Urges States and operators, when assessing the interference risks associated with conflict zones, to consider that the use of satellite-based CNS systems can potentially be impacted beyond those zones.

RESOLUTION COM5/5 (WRC-23)

Prevention and mitigation of harmful interference to the radionavigation-satellite service in the frequency bands 1 164-1 215 MHz and 1 559-1 610 MHz

The World Radiocommunication Conference (Dubai, 2023),

considering

a) that the radionavigation-satellite service (RNSS) in the frequency bands 1 164-1 215 MHz and 1 559-1 610 MHz is used in several aeronautical and maritime communication, navigation and surveillance safety-of-life systems;

b) that the RNSS is used for safety-of-life applications, for scientific applications and in many applications and devices around the world and across all sectors of the global economy, as described in Report ITU-R M.2458;

c) that harmful interference to the RNSS has potential consequences for safety systems used by aeronautical and maritime applications, and for the regularity and efficiency of civil aviation operations;

d) that the International Civil Aviation Organization (ICAO) has taken action to reinforce the resilience to interference of aeronautical positioning, navigation and timing (PNT) systems (see ICAO Assembly Resolution 41-8, Appendix C);

e) that ICAO has established a strategy for retaining essential conventional PNT infrastructure for contingency support in case of RNSS outages, and for developing mitigation techniques for loss of services (see Convention on International Civil Aviation, Annex 10, Vol. I, Att. H); however, such infrastructure and mitigation techniques may not be available in some areas (for example, over the high seas);

f) that the International Maritime Organization (IMO) through its Maritime Safety Committee (MSC), despite actions taken to mitigate the impact of harmful interference on RNSS and its applications, has recognized that harmful interference impacting RNSS poses a substantial risk to the safety of navigation, the safety of life and property, and the protection of the marine environment (see MSC.1/Circ. 1644);

g) that harmful interference to RNSS may be difficult to detect and trace to origin,

recognizing

a) that disruption to RNSS has been identified globally by the aeronautical community and the maritime community;

b) that there are different types of activities, notably the use of unauthorized transmitters, which may cause the disruption;

c) that ICAO decided at its 40th Assembly in October 2019 to take measures to prevent and avoid interference to RNSS;

d) that the Radiocommunication Bureau, in response to a decision of the Radio Regulations Board, issued Circular Letter CR/488, containing recommendations to Member States concerning mitigation of harmful interference to the RNSS;

e) that Article 45 of the ITU Constitution states that "All stations, whatever their purpose, must be established and operated in such a manner as not to cause harmful interference to the radio services or communications of other Member States or of recognized operating agencies, or of other duly authorized operating agencies which carry on a radio service, and which operate in accordance with the provisions of the Radio Regulations";

f) that Article 47 of the Constitution states that "Member States agree to take the steps required to prevent the transmission or circulation of false or deceptive distress, urgency, safety or identification

signals, and to collaborate in locating and identifying stations under their jurisdiction transmitting such signals";

g) that No. **4.10** states that "the safety aspects of radionavigation and other safety services require special measures to ensure their freedom from harmful interference";

h) that No. **5.328A** states that "Stations in the radionavigation-satellite service in the band 1 164-1 215 MHz shall operate in accordance with the provisions of Resolution **609 (Rev.WRC-07)** and shall not claim protection from stations in the aeronautical radionavigation service in the band 960-1 215 MHz. No. **5.43A** does not apply. The provisions of No. **21.18** shall apply";

i) that prevention, identification, reporting and handling of cases of harmful interference, are subject to the provisions of Article **15**;

j) that there are other RNSS applications in the frequency bands 1 164-1 215 MHz and 1 559-1 610 MHz and that there are other RNSS applications operating in other frequency bands that need to be protected and that are not within the scope of this Resolution,

resolves to urge administrations

1 to apply necessary measures to avoid the proliferation, circulation and operation of unauthorized transmitters that cause or have the potential to cause harmful interference to RNSS systems and networks operating in the frequency bands 1 164-1 215 MHz and 1 559-1 610 MHz, including possible measures that might need to be taken with respect to *recognizing j)*;

2 to take the following actions to prevent and mitigate harmful interference affecting RNSS operating in the frequency bands 1 164-1 215 MHz and 1 559-1 610 MHz without prejudice to the right of administrations to deny access to RNSS, for security or defence purposes:

2.1 to encourage collaboration between spectrum regulators, enforcement authorities and RNSS stakeholders, in particular in the aeronautical and maritime domains;

2.2 to encourage cooperation between aeronautical, maritime and security authorities, as well as spectrum regulators, as appropriate, to address interference risks to RNSS systems that may stem from the activities of these security authorities;

3 to report cases, as the affected administration deems appropriate, of harmful interference to RNSS in accordance with Article **15**,

instructs the Director of the Radiocommunication Bureau

to provide, on request, assistance to administrations in accordance with No. **13.2**,

instructs the Secretary-General

to bring this Resolution to the attention of ICAO and IMO.

— END —

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Ref.: T 8/5.10 – AP052/24(CNS) 23 April 2024

Subject: GNSS Interference Reporting Form for APAC

Action Required: To note and consider using the form when appropriate.

Dear Sir/Madam,

I wish to inform you that the Thirty-Fourth Meeting of the Asia/Pacific Air Navigation Planning and Implementation Regional Group (APANPIRG/34) held from 11 to 13 December 2023 reiterated the Global navigation satellite system (GNSS) vulnerability issue.

Considering the reports from flight crew are essential to address GNSS related issues, the Meeting urged States and airspace users (through IATA) to report GNSS occurrences to ICAO APAC Office using the reporting templates which would be circulated in a State Letter, with reference to the paragraph 3.4.41 to 3.4.44 of the Final Report of APANPIRG/34 at: https://www.icao.int/APAC/Meetings/Pages/2023-APANPIRG-34.aspx.

The Eighth Meeting of the Spectrum Review Working Group (SRWG/8) of APANPIRG was held in ICAO APAC Regional Office from 5 to 7 March 2024, the SRWG/8 adopted the example forms for GNSS Interference Reporting to States through **Decision SRWG/8/5** – *GNSS Interference Reporting Form for APAC*, which are provided in **Attachment** to this letter. The electronic version in Microsoft Word format of the GNSS Interference Reporting Form for APAC can also be accessed at: https://www.icao.int/APAC/Meetings/Pages/2024-SRWG8.aspx.

Normally, GNSS outage or anomaly reports should be filed with the State where the outage occurred, the **Attachment** of this letter includes two reporting forms that can be used for that purpose. States and/or Air navigation services providers are encouraged to share lessons learned in corresponding aviation forums (spectrum-related working groups), however, GNSS Radio frequency interference (RFI) reporting to ICAO does in no way replace the reporting requirements identified within an individual State, it shall be limited to the reporting of cases with cross-border impact that cannot be solved nationally or internationally through routine procedures, including the application of all suitable measures for dealing with interference laid down in Article 15 of the ITU Radio Regulations.

For any further questions, please contact Mr. Luo, Yi, Regional Officer, Communications, Navigation and Surveillance at yluo@icao.int; apac@icao.int .

Yours sincerely,

for Tao Ma
Regional Director

Enclosure: Attachment: GNSS Interference Reporting Form for APAC

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SRWG/8
Appendix F to the Report

GNSS Interference Reporting Form for APAC
1.Example form for use by ATS Personnel

GNSS RFI REPORTING FORM FOR USE BY ATS PERSONNEL	
Originator of report	
Organization	
Department	
Street address	
Zip code/city	
Name/surname	
Phone number	
E-Mail	
Date and time of report	
Description of interference	
Source of initial interference report	[ ] Pilot [ ] Engineer/technician [ ] Other
Observability of the interference	Interference was noticeable: [ ] only on board the aircraft (flying, not on the ground)

GNSS RFI REPORTING FORM FOR USE BY ATS PERSONNEL	
	[ ] only on the ground (aircraft parked/taxiing) or by means of ground detection systems available [ ] both
Number of received reports	
Coordinates of the area of occurrence/time (UTC)	UTC: ___Lat: ____Long: ____FL/Altitude: ____
Problem duration:	Days, hours, minutes, seconds _____ [ ] continuous [ ] intermittent
Affected GNSS element	[ ] GPS [ ] GLONASS [ ] GALILEO [ ] BDS [ ] Other constellation [ ] EGNOS [ ] WAAS [ ] BDSBAS [ ] Other SBAS [ ] GBAS (VHF data-link for GBAS)
Affected constellation frequency	[ ] L1 [ ] L5 [ ] Both
Used GNSS contingency procedure	[ ] Radar vectoring [ ] Switch to procedures based on conventional navaids (e.g. DME/DME or VOR/DME-based PBN, DME and VOR-based conventional, ILS) [ ] Diversion to another airport [ ] Missed approach [ ] Use of alternate means for communication (e.g. VHF) [ ] Other: ___
In case of report by pilot	
Airline name	
Aircraft type and registration	
Flight number	
Airway/route flown	
Reported on-board failure	[ ] Total loss of navigation capabilities [ ] Need to change the navigation procedure [ ] Inability to fly RNP and request for radar vectoring [ ] Inability to fly a GNSS-based approach (GLS, SLS) [ ] GNSS fault (1 or 2) [ ] TAWS/EGPWS warnings or loss of terrain and surface functionalities [ ] Loss of ADS-B [ ] Wind and ground speed wrong presentations [ ] Aircraft clock anomaly [ ] Loss of situational awareness (SVS, Cockpit Display of Traffic Information)

GNSS RFI REPORTING FORM FOR USE BY ATS PERSONNEL	
	[ ] Loss of communication functions (CPDLC, ACARS) [ ] AHRS failure [ ] Map shift [ ] Other: ___
Information on presumed source of interference	
Presumed location of interference source	Lat: ___Long: ____ or Nearest city or landmark:
Interfering frequency (if known)	
Signal strength and reference bandwidth (if known)	
Further descriptions of the interference case	[ ] Spectrum plot [ ] Map [ ] Other material:

2.Example form for use by pilots

GNSS RFI REPORTING FORM FOR USE BY PILOTS	
Originator of report	
Organization	
Department	
Street address	
Zip code/city	
Name/surname	
Phone number	
E-mail	
Date and time of report	
Description of interference	
Reported failure and operational impact	[ ] Total loss of navigation capabilities [ ] Need to change the navigation procedure [ ] Inability to fly RNP and request for radar vectoring [ ] Inability to fly a GNSS-based approach (GLS, SLS) [ ] GNSS fault (1 or 2) [ ] TAWS/EGPWS warnings or loss of terrain and surface functionalities

	[ ] Loss of ADS-B [ ] Wind and ground speed wrong presentations [ ] Aircraft clock anomaly [ ] Loss of situational awareness (SVS, Cockpit Display of Traffic Information) [ ] Loss of communication functions (CPDLC, ACARS) [ ] AHRS failure [ ] Map shift [ ] Other: ___
Used GNSS contingency procedure	[ ] Request for radar vectoring [ ] Switch to another mean of navigation (e.g. DME/DME, VOR/DME, ILS) [ ] Diversion to another airport [ ] Missed approach [ ] Use of alternate means for communication (e.g. VHF) [ ] Other: ___
Affected GNSS element	[ ] GPS [ ] GLONASS [ ] GALILEO [ ] BDS [ ] other constellation [ ] EGNOS [ ] WAAS [ ] BDSBAS [ ] other SBAS [ ] GBAS (VHF data-link for GBAS)
Affected constellation frequency	[ ] L1 [ ] L5 [ ] Both
Aircraft type and registration	
Flight number	
Airway/route flown (airport RWY/gateway/parking gate in case of on-ground detection)	
Coordinates of the area of occurrence/time (UTC)	UTC: ___Lat: ____Long: ____FL/Altitude: ____
Problem duration	Days, hours, minutes, seconds _____ [ ] continuous [ ] intermittent

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Tel.: +1 514-315-1872

30 April 2024

Ref.: E 3/5-24/54

Subject: Aviation **s**afety concerns regarding interference to the Global Navigation Satellite System (GNSS)

Action required: a) disseminate guidance material; and b) implement recommendations, as applicable

Sir/Madam,

1. I have the honour to bring to your attention the concerning escalation of jamming and spoofing activities targeting the global navigation satellite system (GNSS), which have been increasingly observed recently in various regions globally. GNSS, as one of the main enablers for performance-based navigation (PBN), provides navigation guidance for all phases of flight, from enroute through to precision approach. By providing accurate position and timing information, GNSS enables several systems critical to the safety of flight.

2. Since 2003, the International Civil Aviation Organization (ICAO) has been actively developing recommendations and guidance concerning GNSS Radio Frequency Interference (RFI). It is pertinent to recall ICAO Assembly Resolution A41-8, Appendix C: *Ensuring the resilience of ICAO CNS/ATM systems*, which serves as the latest ICAO policy on GNSS resilience.

3. To bring attention to the critical issue of GNSS interference, and to foster discussions on the management of GNSS vulnerabilities and potential mitigation measures against GNSS RFI, ICAO recently convened the ICAO EUR/MID Radion Navigation Symposium from 6 to 8 February 2024 in Antalya, Turkey. One important outcome of this symposium is the attached list of recommendations regarding Stakeholders' continued efforts towards ensuring safe, reliable, and resilient air navigation.

4. I would like to take this opportunity to refer to recent safety-related publications by the European Union Aviation Safety Agency (EASA), Safety Information Bulletin No. 2022-02R2 and the Federal Aviation Administration (FAA), Safety Alert for Operators (SAFO 24002).

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5. You are kindly requested to consider and disseminate as appropriate, the guidance material provided in the above links to all relevant entities in your State, and to consider the attached recommended actions, as applicable.

Accept, Sir/Madam, the assurances of my highest consideration.

Juan Carlos Salazar
Secretary General

Enclosure:
Recommendations from the ICAO EUR/MID Radio Navigation Symposium (6 to 8 February 2024)

ATTACHMENT to State letter E 3/5-24/54

ICAO EUR/MID Radio Navigation Symposium
Antalya, Turkey (6 to 8 February 2024)

RECOMMENDATIONS

Recognizing with concern the impact of global navigation satellite system (GNSS) Radio Frequency Interference (RFI) on aviation safety, capacity, efficiency and security, the Symposium recalled and underlined Resolution A1-8, Appendix C: Ensuring the resilience of ICAO CNS/ATM systems and services *and agreed on the need to take necessary actions to ensure continued safe, reliable, and resilient air navigation.*

The Symposium recommended:

- ***All Stakeholders*** to be aware of the potential safety and capacity impacts of GNSS interference, jamming, and spoofing.

- ***Civil Aviation Authorities (CAAs)*** to ensure that air navigation service providers (ANSPs) deploy and maintain adequate distance measuring equipment (DME) infrastructure and DME based Performance-Based Navigation (PBN) procedures and enable aircraft operators use of multi-DME and multi-DME/inertial reference system (IRS) complementary solutions as appropriate to maintain PBN operations during GNSS local or regional interference, jamming or spoofing.

- ***CAAs*** to ensure that air navigation services providers (ANSPs) implement and maintain necessary minimum operational networks (MON), or greater, of navigation aids and radar infrastructures (including very high frequency omnidirectional radio range (VOR), instrument landing system (ILS) Cat I/II/III and DME) to ensure the necessary levels of resilience for navigation when core constellations, satellite-based augmentation system (SBAS) or ground-based augmentation system (GBAS) are unusable.

- ***ANSPs*** to develop contingency procedures (technical and operational) for GNSS radio frequency interference (RFI) events, to minimize any operational impact and ensure continuous safe operation of air traffic. The contingency procedure may require the provision of reliable surveillance coverage that is resilient to GNSS interference.

- ***ANSPs*** to implement/maintain a GNSS-independent time source for synchronisation of relevant Communications, Navigation and Surveillance/Air Traffic Management (CNS/ATM) infrastructure.

- ***CAAs/ANSPs*** to facilitate or deploy as appropriate real-time monitoring and detection solutions for GNSS RFI situational awareness for all stakeholders, while recognizing that only the aircraft operator is responsible for determining their ability to navigate.

- ***ANSPs*** to issue notice to airmen (NOTAMs) on GNSS RFI events in a timely manner; to establish coordination arrangements with neighbouring flight information regions (FIRs) on how to best to share their navigation infrastructures in the event of GNSS RFI and any resulting air traffic diversion.

- ***CAAs/ANSPs*** to improve civil-military coordination to address interference risks associated with GNSS testing and conflict zones, to ensure the uninterrupted and reliable operation of navigation systems in diverse applications.

- ***National Military Authorities*** to coordinate with National Spectrum Regulators, CAAs and ANSPs, to the extent possible, ahead of any necessary GNSS RFI activity. This will enable ANSPs to mitigate any safety impact on civil aviation.

- ***CAAs*** to foster collaboration with their National Spectrum Regulators regarding GNSS RFI.

- ***National Spectrum Regulators*** to locate and determine the source of reported GNSS RFI and attempt to resolve it, as appropriate. The GNSS RFI resolution may require coordination with other authorities at national or regional levels.

- ***National Spectrum Regulators*** to report frequent unresolved GNSS RFI incidents to the Radiocommunication Bureau of the International Telecommunication Union (ITU), describing GNSS RFI impact as experienced within their national borders, or as reported by their registered aircraft.

- ***Aircraft Operators*** to develop a procedure requesting crew to notify air traffic control (ATC) whenever GNSS RFI events are experienced and notify respective aircraft and avionic original equipment manufacturers (OEMs) and State of Aircraft design's CAA through normal safety channels when safety effects are encountered.

- ***Aircraft Operators*** to develop procedures and training based upon information received from aircraft and avionics OEM and State of aircraft design's CAA.

- ***Aircraft Operators*** to place additional emphasis on flight crews closely monitoring aircraft equipment performance for any discrepancies or anomalies, promptly informing ATC of any apparent GNSS degradation, and being prepared to operate without GNSS navigation systems.

- ***Original Equipment Manufacturers (OEMs)*** to improve their equipment and provide further guidance and information on the effects and mitigations of GNSS RFI (including interference, jamming and spoofing) from the perspective of aircraft equipment.

- ***OEMs*** to ensure that aircraft equipment quickly recovers and resumes GNSS navigation once not impacted anymore by a GNSS RFI event.

- ***ICAO Navigation Systems Panel (NSP)*** to develop recommendations on how to share information on GNSS RFI (NOTAM or other measures).

- ***All stakeholders*** to collaborate towards developing simple and automated common reporting of GNSS RFI.

- ***All stakeholders*** to continue to evolve solutions, while leveraging the ICAO NSP as a common focal point.

- ***ICAO*** to continue raising awareness and supporting States, as required.

— END —

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Tel.: +1 514-315-1872

Ref.: E 3/5-24/54 30 April 2024

Subject: Aviation **s**afety concerns regarding interference to the Global Navigation Satellite System (GNSS)

Action required: a) disseminate guidance material; and
b) implement recommendations, as applicable

CORRIGENDUM OF 13 MAY 2024
(English only)

Please note:

a) the symposium title, in paragraph 3, should be amended to read "…the ICAO EUR/MID Radio Navigation Symposium…"; and
b) the State name, in paragraph 3, and the title of the Attachment, should be amended to read "Antalya, Türkiye.".

— END —

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