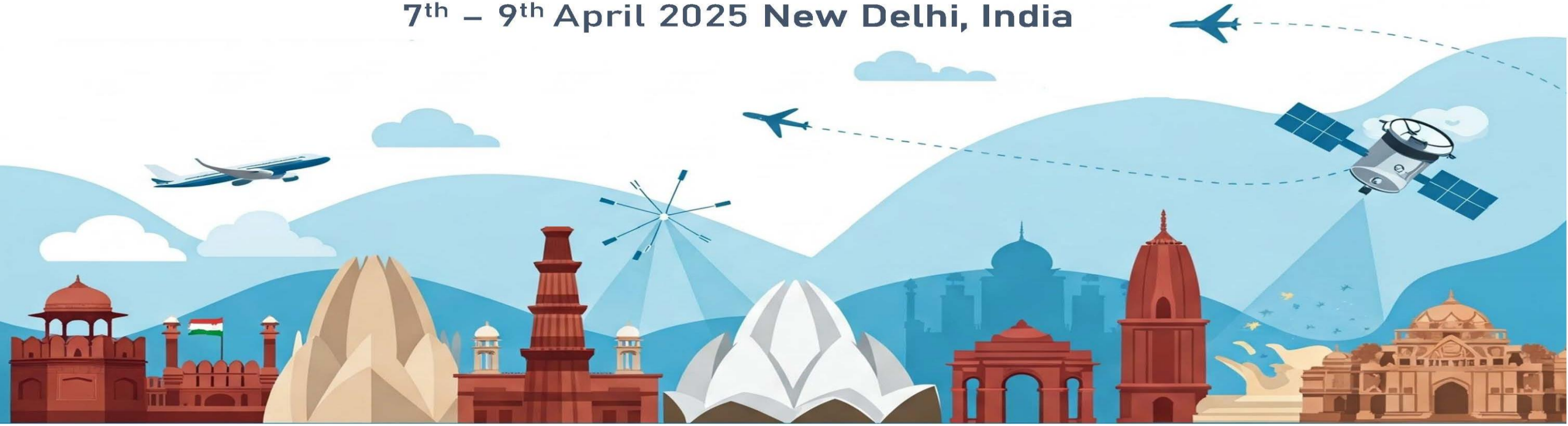
नागर विमानन मंत्रालय
MINISTRY OF CIVIL AVIATION

भारतीय विमानपत्तन प्राधिकरण
AIRPORTS AUTHORITY OF INDIA

ICAO APAC RADIO NAVIGATION SYMPOSIUM

GNSS RFI: Collectively Bridging Gaps and Shaping the Path Forward

7th – 9th April 2025 New Delhi, India



ICAO provisions and Global Developments

Muna Alnadaf
Technical Officer/CNS – ICAO HQ

Presentation Overview

ICAO Relevant Provisions

Annex and guidance material

Global Developments

ICAO events & initiatives

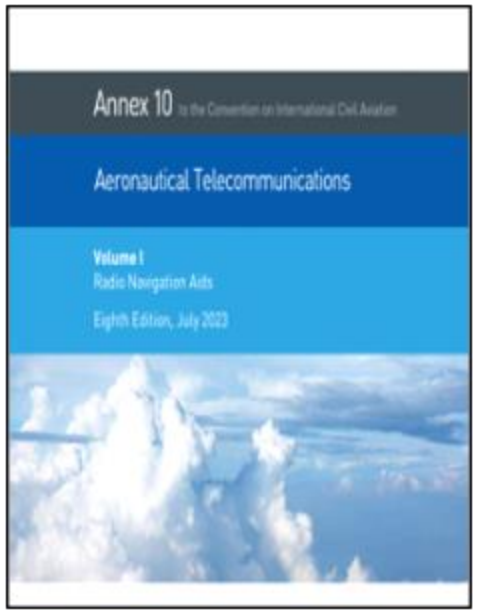
NSP Activities

Completed and Ongoing Activities

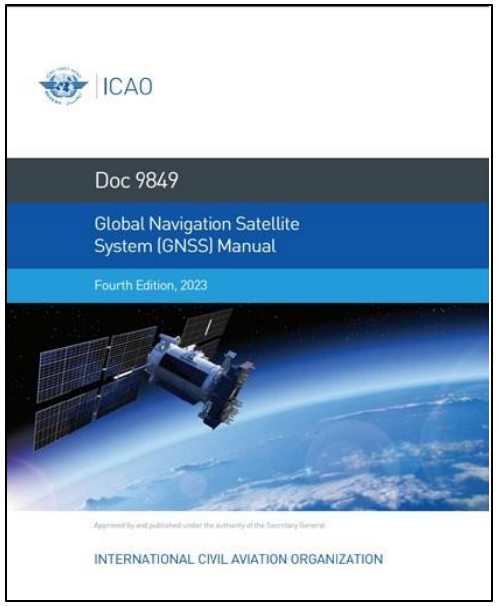
NSP Action Plan

In response to the outcome of AN-Conf/14

Relevant ICAO Provisions



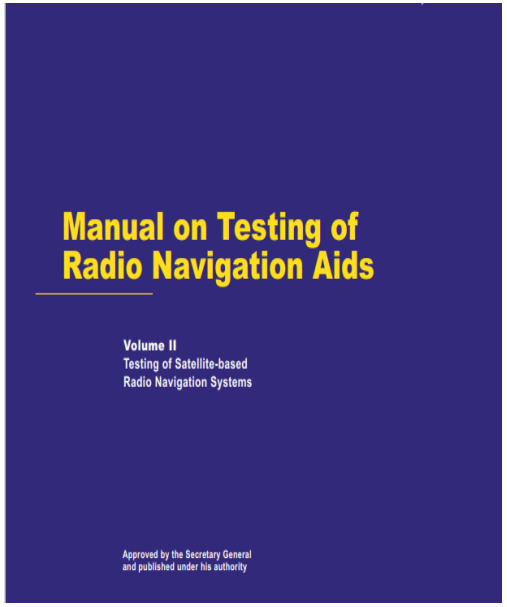
Annex 10, Vol I



ICAO Doc 9849, Global Navigation Satellite System (GNSS) Manual

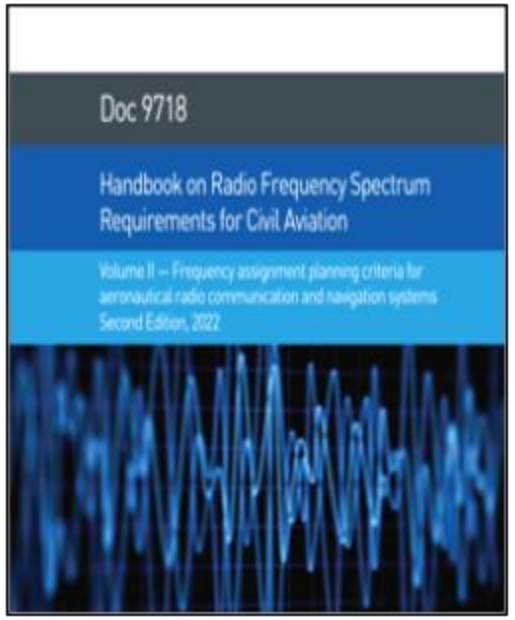
ICAO Doc 8071, Vol I, Testing of Ground based Radio Navigation Systems

Relevant ICAO Provisions

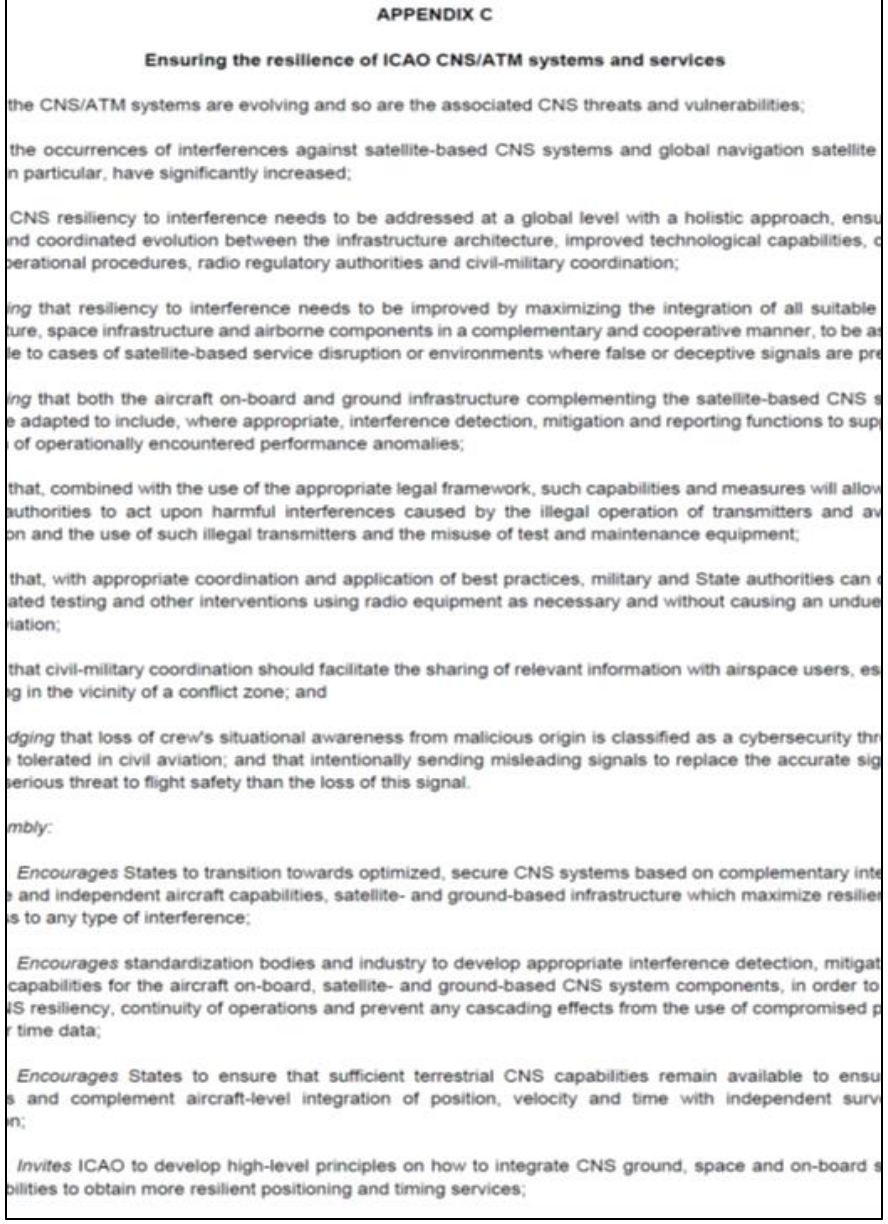


ICAO Doc 8071, Vol II, Manual on Testing of satellite based Radio Navigation Systems

ICAO Doc 9718, Handbook on Radio Frequency Spectrum Requirements for Civil Aviation



ICAO Doc 9718 Vol II, Frequency assignment criteria for aeronautical radio communication & navigation systems



APPENDIX C

Ensuring the resilience of ICAO CNS/ATM systems and services

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

the occurrences of interferences against satellite-based CNS systems and global navigation satellite
n particular, have significantly increased;

CNS resiliency to interference needs to be addressed at a global level with a holistic approach, ensu
nd coordinated evolution between the infrastructure architecture, improved technological capabilities, c
erational procedures, radio regulatory authorities and civil-military coordination;

ng that resiliency to interference needs to be improved by maximizing the integration of all suitable
ture, space infrastructure and airborne components in a complementary and cooperative manner, to be a
le to cases of satellite-based service disruption or environments where false or deceptive signals are pr

ng that both the aircraft on-board and ground infrastructure complementing the satellite-based CNS s
e adapted to include, where appropriate, interference detection, mitigation and reporting functions to sup
of operationally encountered performance anomalies;

that, combined with the use of the appropriate legal framework, such capabilities and measures will allow
uthorities to act upon harmful interferences caused by the illegal operation of transmitters and av
on and the use of such illegal transmitters and the misuse of test and maintenance equipment;

that, with appropriate coordination and application of best practices, military and State authorities can
ated testing and other interventions using radio equipment as necessary and without causing an undue
iation;

that civil-military coordination should facilitate the sharing of relevant information with airspace users, es
g in the vicinity of a conflict zone; and

dging that loss of crew's situational awareness from malicious origin is classified as a cybersecurity thr
tolerated in civil aviation; and that intentionally sending misleading signals to replace the accurate sig
erious threat to flight safety than the loss of this signal.

mbly:

Encourages States to transition towards optimized, secure CNS systems based on complementary inte
and independent aircraft capabilities, satellite- and ground-based infrastructure which maximize resilie
s to any type of interference;

Encourages standardization bodies and industry to develop appropriate interference detection, mitigat
capabilities for the aircraft on-board, satellite- and ground-based CNS system components, in order to
IS resiliency, continuity of operations and prevent any cascading effects from the use of compromised p
time data;

Encourages States to ensure that sufficient terrestrial CNS capabilities remain available to ensu
s and complement aircraft-level integration of position, velocity and time with independent surv
n;

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

ICAO 41st Assembly

The 41st Session of the Assembly, Resolution A41-8, Appendix C, ICAO policy on GNSS (and more generally CNS systems) resilience

ICAO EUR/MID Radio Navigation Symposium (Feb 2024)

ICAO organized a Radio Navigation Symposium with the focus on GNSS RFI for ICAO EUR & MID Regions.

SL dated 30 April 2024 circulated the outcome of the symposium and requested States to disseminate the guidance material and implement recommendations, as applicable.

International Civil Aviation Organization | Organisation de l'aviation civile internationale | Organización de Aviación Civil Internacional | Международная организация гражданской авиации | منظمة الطيران المدني الدولي | 国际民用航空组织

Tel.: +1 514-315-1872

30 April 2024

Ref.: E 3/5-24/54

Subject: Aviation safety 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).

Recommendation 2.2/2 – Addressing GNSS interference & contingency planning

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 global navigation satellite system interference;**

b) through the mechanism of the planning and implementation regional groups, develop regional **global navigation satellite system** reporting mechanisms**, to the extent feasible, to raise operational awareness of affected geographical areas as described in the Global Navigation Satellite System (GNSS) Manual (Doc 9849);**

c) work with industry to identify means to make aircraft systems more resilient to radio frequency interference events, and to provide guidance on detecting global navigation satellite system jamming or spoofing and maintaining safe and efficient aircraft operation in case of global navigation satellite system anomalies; and

d) review aircraft minimum equipage lists to ensure compatibility with States' implemented minimum operational networks.

AN-Conf/14

Recommendation 2.2/2 – Addressing GNSS interference & contingency planning

That ICAO:

e) continue to assess the impact of global navigation satellite system interference on aviation safety and continuity of civil aviation operations and define adequate mitigation measures**, while reminding States of their obligations;**

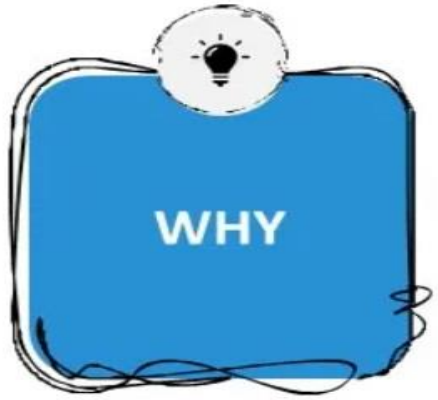
f) develop **a standardized** implementation package to assist and guide States in implementing effective **global navigation satellite system radio frequency interference** mitigation measures**, including optimization and rationalization of conventional navigation aids, commensurate with their local conditions, to ensure continuity in the provision of air navigation services;**

g) develop guidance on GNSS interference information exchange **and** civil-military coordination **in relation to harmful interference to global navigation satellite system(s) originated or detected by military authorities; and**

H) develop recommendations for globally harmonized minimum aircraft equipage lists to ensure that provided navigation infrastructure can be used by airspace users in line with available air traffic services.

iPack for mitigation of GNSS RFI

To develop standardized implementation package (iPack) for mitigation of GNSS RFI



To support States in managing GNSS RFI incidents and to ensure the continuous provision of safe and efficient air navigation services

ICAO and Pool of subject matter experts from relevant Experts group

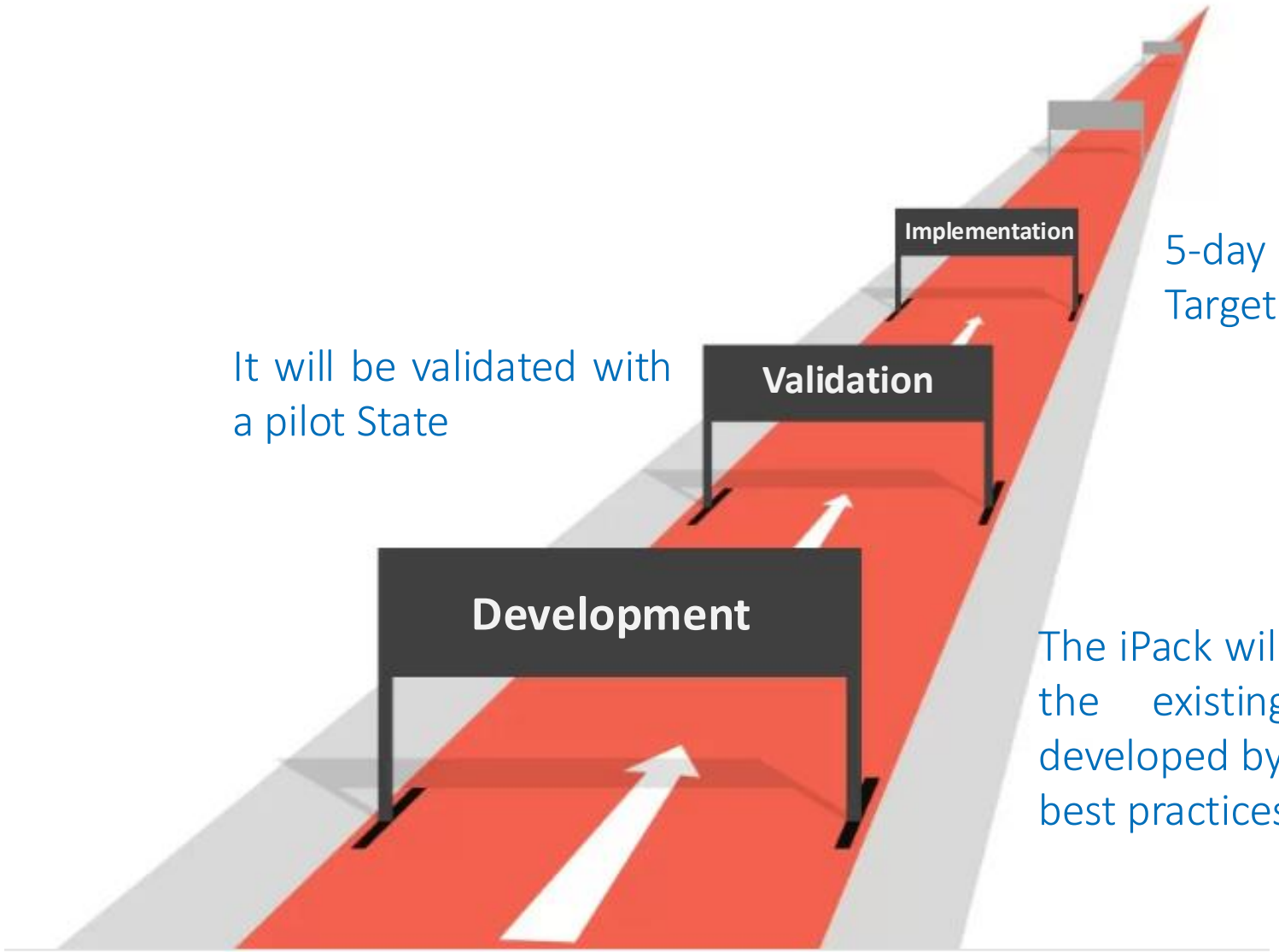
By assisting States in implementing necessary preventive and reactive mitigation measures to reduce the likelihood and impact of GNSS RFI.

iPack for mitigation of GNSS RFI

The iPack will involve:

1. raising awareness on the potential impact of GNSS RFI on CNS/ATM systems and GNSS based services and operational applications;
2. conducting GNSS RFI risk mitigation framework by using the 3-steps process of threat monitoring, risk assessment and deployment of mitigation measures;
3. assisting States in developing required policy, procedures, processes and training requirements (ex. Coordination with Mil, TRA and adjacent states, monitoring mechanisms, Reporting procedures, ATC training, …etc)
4. assessing the conventional navigation and surveillance infrastructure to establish backup/ complementary procedures in case of GNSS RFI “right sizing rationalization”; and
5. develop States action plan to implement mitigation measures.

iPack for mitigation of GNSS RFI



5-day national Workshop
Target date Q2/Q3 2025

It will be validated with a pilot State

The iPack will be developed based on the existing guidance materials developed by ICAO & other ORGs and best practices from different regions

Awareness Activities

- The AN-Conf/14 requested ICAO to continue awareness activities and noted the planned Regional Workshops

  - ✓ EUR/MID Radio Navigation Symposium, Feb 2024
  - ✓ ACAO/ICAO Radio Navigation Workshop, Feb 2025
  - ❑ ICAO APAC Radio Navigation Symposium, 7-9 April 2025
  - ❑ ICAO NAM/SAM Radio Navigation Workshop, 2-4 September 2025

Electronic Bulletin

Disseminated the OPSGroup Report for information & awareness (EB 2024/27)

International Civil Aviation Organization

ELECTRONIC BULLETIN

For information only

EB 2024/27 — 18 December 2024

REPORT OF THE OPSGROUP GPS SPOOFING WORKGROUP

1. On 4 November 2024, the Council of the International Civil Aviation Organization (ICAO) was briefed on a report providing the outcomes of an impact assessment on Global Positioning System (GPS) Spoofing, developed by a Working Group of the OPSGROUP. Membership of the OPSGROUP consists primarily of pilots, flight dispatchers, schedulers and controllers. The report provides comprehensive information on the recent increase in GPS Spoofing incidents, their operational impact and various safety concerns.

2. On 5 November 2024, the Council in its 7th meeting of the 233rd session reiterated its serious concerns regarding the impact of interference to the Global Navigation Satellite Systems (GNSS) on the safety and security of air navigation systems, particularly as such occurrences are expected to increase, posing an ever-growing safety hazard to global flight operations. Consequently, the Council has requested (C-DEC 233/7) that the attached report be circulated amongst Member States and relevant industry stakeholders.

3. The Report of the OPSGROUP GPS Spoofing Workgroup, which was published on 6 September 2024, includes detailed analysis of the technical background, impacts to aircraft handling and operation, best practices for flight crew, and a series of safety concerns and recommendations for industry attention.

4. The Report of the OPSGROUP is herewith attached for information and awareness of Member States and industry stakeholders.

Enclosure:
GPS-Spoofing-Final-Report-OPSGROUP-WG-OG24 (English only)

Issued under the authority of the Secretary General

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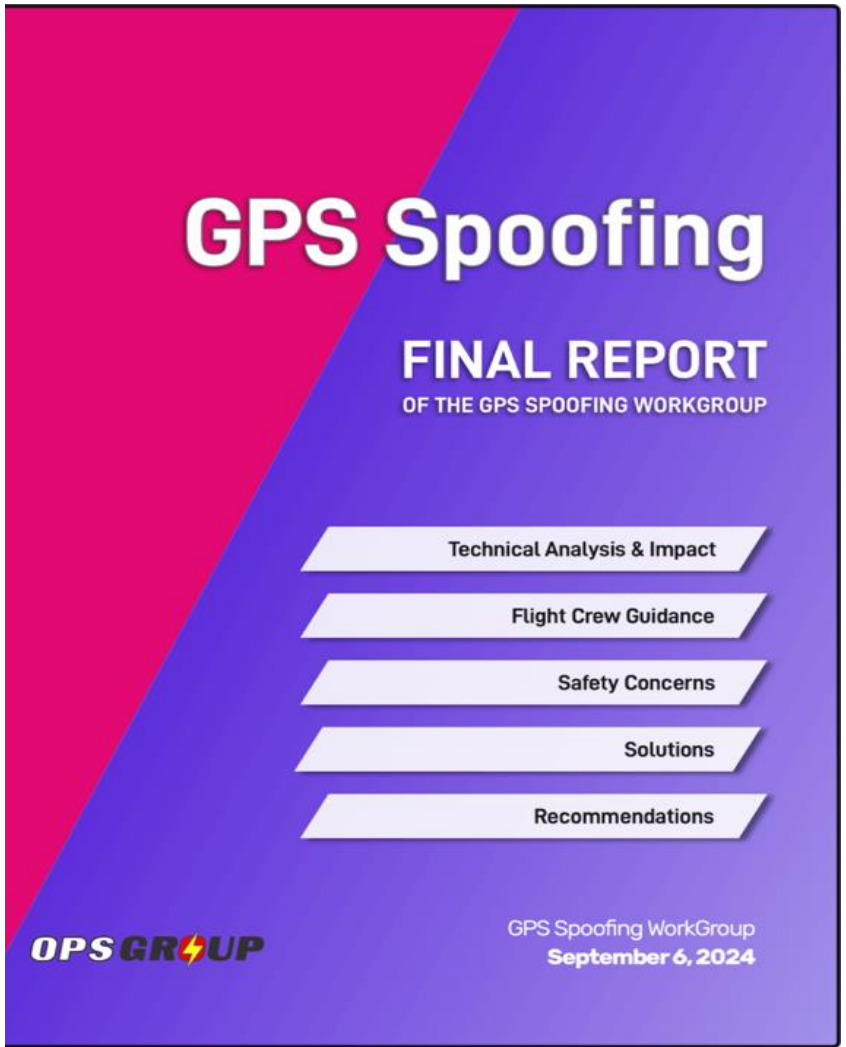
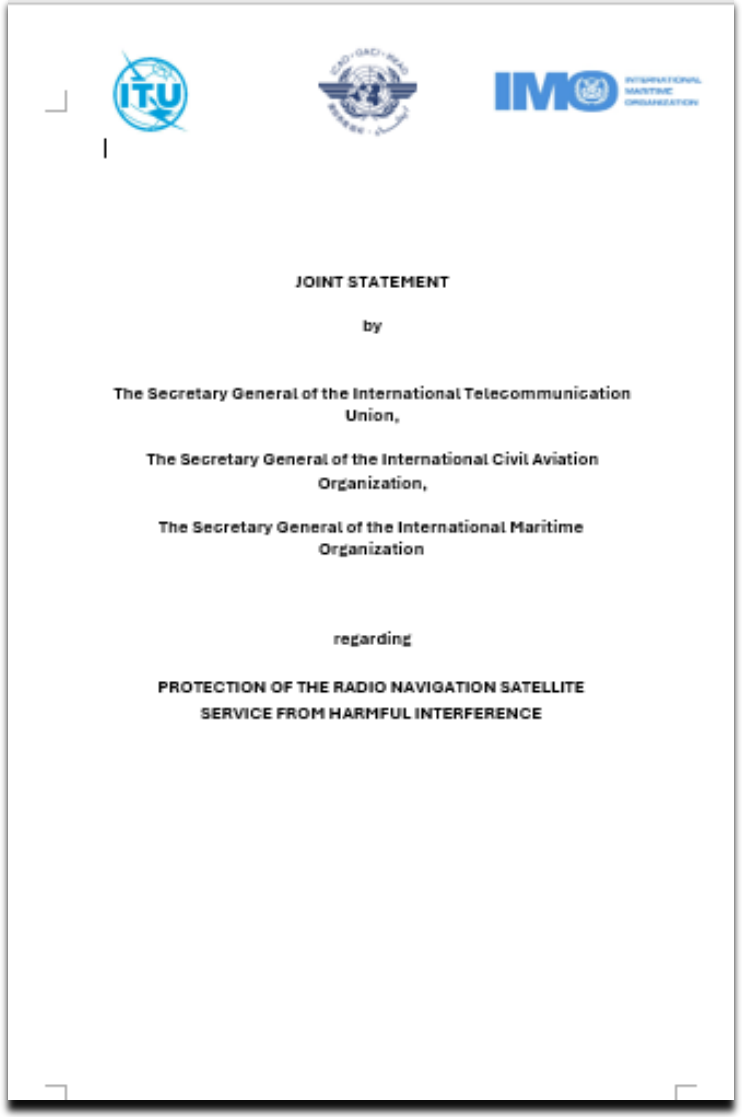
Canada H3C 5H7

ICAO

OPSGroup Report

Issued September, 2024





JOINT STATEMENT

by

The Secretary General of the International Telecommunication Union,

The Secretary General of the International Civil Aviation Organization,

The Secretary General of the International Maritime Organization

regarding

PROTECTION OF THE RADIO NAVIGATION SATELLITE SERVICE FROM HARMFUL INTERFERENCE

Joint Statement by ITU, ICAO, & IMO regarding the protection of Radio Navigation Satellite System (RNSS) from harmful interference

Joint Statement by ITU, ICAO, and IMO

a Protect RNSS

protect the RNSS from transmissions that can adversely cause harmful interference degrading, interrupting or misleading signals used for civilian and humanitarian purposes;

b Reinforce Resilience

reinforce resilience of the systems which rely on RNSS for navigation, positioning and timing in relation to this type of interference;

c Retain Infrastructure

retain sufficient conventional navigation infrastructure for contingency support in case of RNSS outages and misleading signals, and develop mitigation techniques for loss of services;

d Increase Collaboration

increase collaboration between radio regulatory, civil aviation, maritime, defense and enforcement authorities; and

e Report Interference

report cases of harmful interference affecting RNSS to the appropriate telecommunication, aeronautical and maritime authorities, and to the ITU Radiocommunications Bureau, to enable the monitoring of the situation.

ICAO Navigation Systems Panel (NSP)

- Was established in 2003
- Composed of 28 members from States and organizations.
- NSP members & advisors are experts involved in design, development, planning, implementation and operation of aeronautical navigation systems

- To develop, as required, SARPs and guidance material pertaining Radio navigation. It should also Monitor the development and implementation of aeronautical navigation systems and facilities in order to facilitate worldwide coordination of implementation;

NSP Activities

Complete

- Amendment 94 of Annex 10, Vol 1:

ICAO State Letter (PfA) 2023/67 sent 31 October 2023

Adoption of amendment SL will be circulated soon

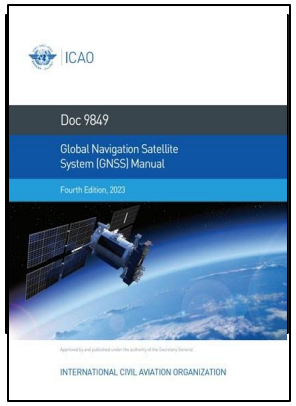
Amendment 94 applicability: 27 November 2025

- Developed guidance material on reduction of flight inspection runs

Updated version of the 8071, Vol I will be published by end of 2025

NSP Activities

In-Progress



Update to GNSS Manual (Doc 9849) guidance on the detection, reporting, and resolution of GNSS RFI, and to add provisions intended for GNSS providers on publication of service performance standards, regular performance assessment and notification of events that may affect the service.

- **Target Applicability: June 2026**

ConOps

Develop a concept of operation for next generation equipment functions to improve navigation service robustness in the presence of RFI to GNSS

- Target Applicability: May 2025

NSP Activities

- SARPs for SBAS Provider optional “Data Message” authentication capability

  Target Applicability: Nov 2028

- SARPs and guidance material to support GBAS via multiple constellations and frequencies

  Target applicability Nov 2033

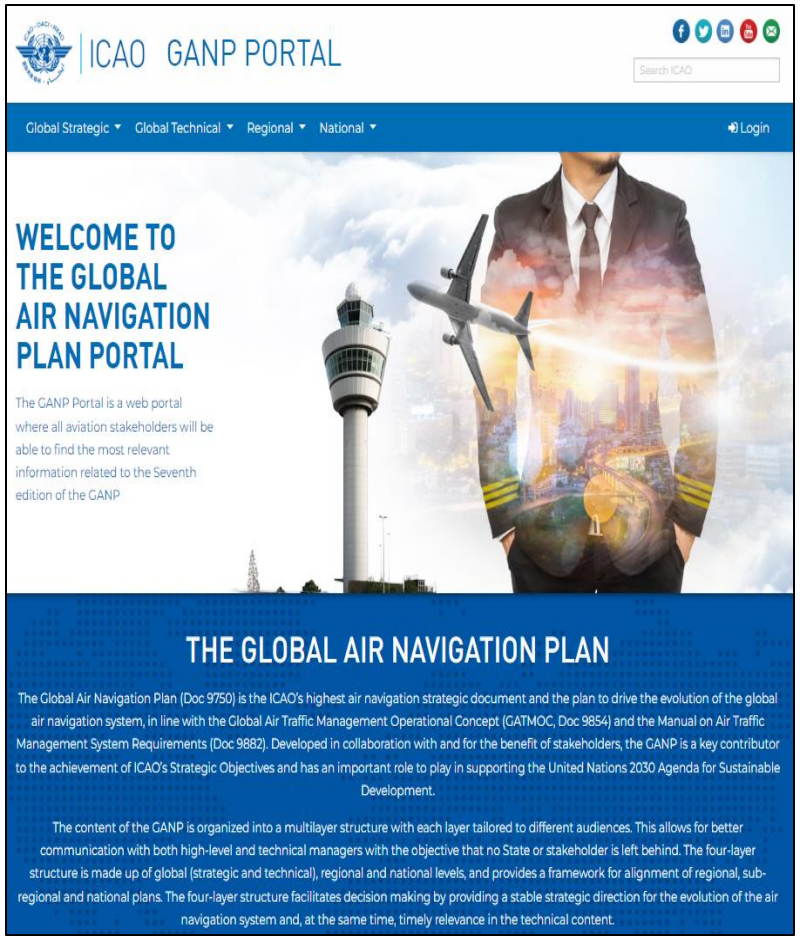
NSP Activities

- Update Manual on Testing Navaids (Doc 8071) guidance on detection, classification, localisation and resolution (including mitigation) of GNSS RFI

  Target Applicability: June 2026 applicability

- Update the Alternative-PNT Job Card to take Assembly Resolution A41-8C on Complementary PNT into account.

NSP Activities



GANP: Updating NAVS

NAVS

NAVS-B0/1	Ground Based Augmentation Systems (GBAS)
NAVS-B0/2	Satellite Based Augmentation Systems (SBAS)
NAVS-B0/3	Aircraft Based Augmentation Systems (ABAS)
NAVS-B0/4	Navigation Minimal Operating Networks (Nav. MON)
NAVS-B1/1	Extended GBAS
NAVS-B2/1	Dual Frequency Multi Constellation (DF MC) GBAS
NAVS-B2/2	Dual Frequency Multi Constellation (DF MC) SBAS
NAVS-B2/3	Dual Frequency Multi Constellation (DF MC) ABAS

NSP Action Plan (AN-Conf/14, Rec. 2.2/2)

Develop further guidance material on GNSS Spoofing, that will include:

- effect of spoofing on navigation and timing capabilities
- possible side effect of GNSS interference on other air navigation services, notably Communication / Surveillance as well as other capabilities in the aircraft (in cooperation with other relevant ICAO panels and notably the Flight Ops Panel)
- reversion to alternate navigation capabilities based on conventional navaids (in close cooperation with CNTWG)
- possible reversion capabilities for a reliable timing service in case of unreliable or unavailable GNSS

NSP Action Plan (AN-Conf/14, Rec. 2.2/2)

The need for additional NOTAM Codes for GNSS RFI and GBAS

Agreed on the need to have Q code(s) for GNSS RFI and recommended item E text, however the group agreed on the need to develop guidance
material on how to interpret and deal with GNSS RFI NOTAMs (need for
inter-panel Coordination)

The work to be concluded in NSP JWGs/14 meeting in May 2025

NSP Action Plan (AN-Conf/14, Rec. 2.2/2)

The need for additional NOTAM Codes for GNSS RFI and GBAS

Based on prior implementations and a significant operational history that no additional NOTAM codings are required to differentiate between GBAS ground station and constellation failures.

NSP Action Plan (AN-Conf/14, Rec. 2.2/2)

The need for the developing guidance on GNSS RFI reports and information sharing and establishing a global repository

Offline RFI reporting: This corresponds to the typical reporting done through pilots, ATC, ANSPs or States towards ICAO. The timeline for such reporting is very long and can take several weeks or months before the information is reported, analysed and transmitted to ICAO.

The group agreed that setting up such centralized database at ICAO level would be unnecessary and could be done at national/ regional level

NSP Action Plan (AN-Conf/14, Rec. 2.2/2)

Online reporting: this would correspond to a near real time reporting of the interference situation to a centralized database operated by ICAO.

The group noted that many States and Regions are already developing such a capacity. The development of a centralized solution has **significant feasibility issues** and would require **lengthy harmonization processes**. which may be detrimental to setting up such a capability at a faster pace in a more agile environment. This would also raise the question of reliability of the information collected and submitted by different parties.

Its recommended that solutions for near realtime interference reporting is organized at State or Regional level where the local constraints can better be taken into account and where the tools to be developed will be better suited to the need for this particular airspace.

NSP Action Plan (AN-Conf/14, Rec. 2.2/2)

Recommendation 2.2/2e “continue to assess the impact of global navigation satellite system interference on aviation safety and continuity of civil aviation operations and define adequate mitigation measures

Update current guidance in GNSS Manual on the detection, reporting and resolution of GNSS RFI including spoofing (12-18 months)

Thank you

धन्यवाद