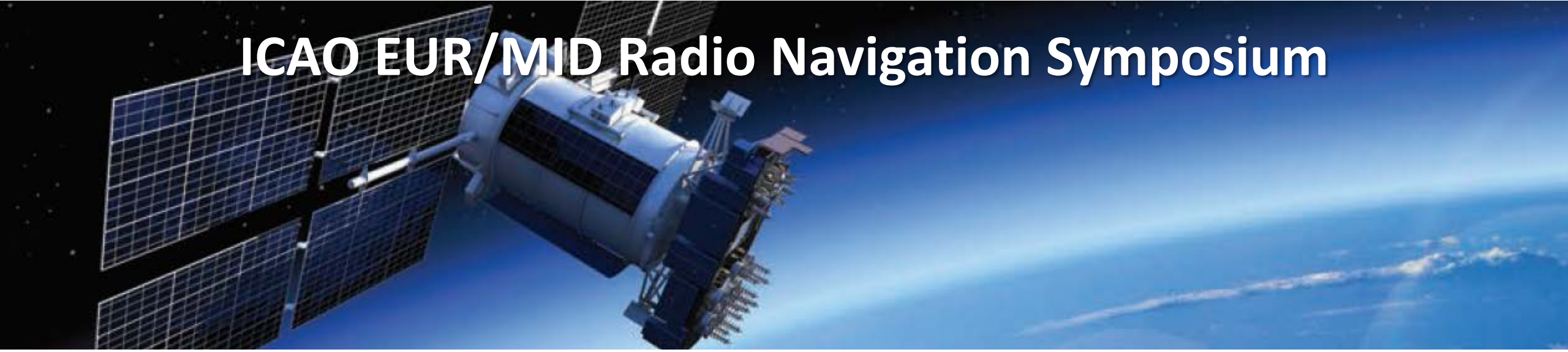


ICAO EUR/MID Radio Navigation Symposium

Session 1.2: Setting the Scene: Global Developments

ICAO Provisions on Radio Navigation and Navigation Systems Panel Activities

Ken Alexander

ICAO Navigation Systems Panel Chairperson

Antalya, Turkiye
(6-8 February 2024)

Brief History of ICAO's Contributions to Radio Navigation

1944 Chicago Convention

ICAO Formed

1949 Annex 10

Introduction of Standards and Recommended Practices (SARPs) for radio navigation aids and communication facilities, together with methods of operation, procedures and codes for worldwide application

1965 Annex 10 Volume I and II

- Vol. I: Equipment and Systems, Radio Frequencies
- Vol II: Communication Procedures

1995 Annex 10 Volumes I - V

- Vol. I: Radio Navigation Aids
- Vol. II: Communication Procedures
- Vol. III: Communication Systems
- Vol. IV: Surveillance Radar and Collision Avoidance Systems
- Vol. V: Aeronautical Radio Frequency Spectrum Utilization

2003 Navigation Systems Panel

ANC 163-10 creates NSP

2023 Eighth Edition

- Dual-Frequency, Multi-Constellation (DFMC) GNSS
- Ionospheric gradient mitigations GBAS

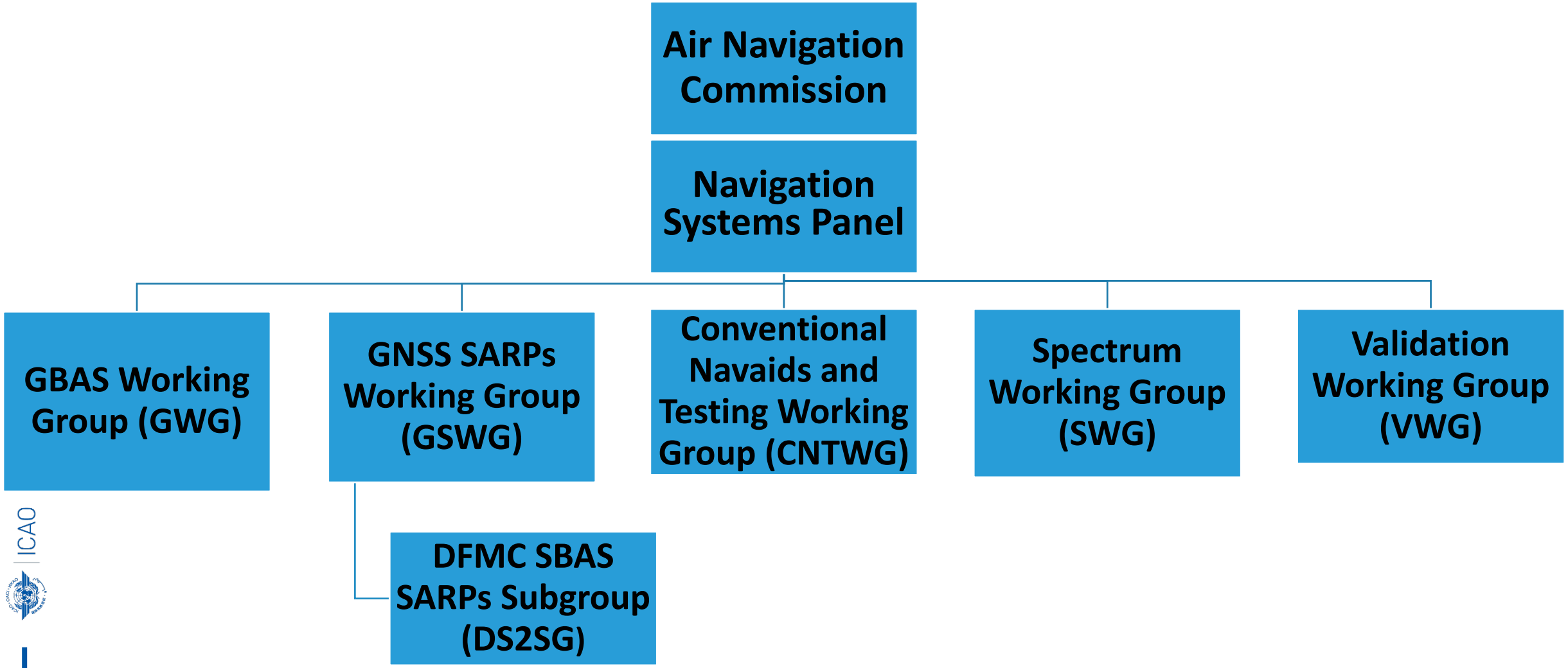
About the Navigation Systems Panel (NSP)

- ICAO serves an essential role in ensuring globally interoperable radio navigation capabilities
- Navigation Systems Panel (NSP) was established in 2003 consistent with Global Navigation Satellite System Panel (GNSSP/4) recommendations
- ANC 163-10 established the NSP work program to define and elaborate on: concepts of use, technical requirements, operational requirements and, where appropriate, technical solutions for aeronautical navigation applications and infrastructure to support them
- NSP is composed of experts involved in design, development, planning, implementation and operation of aeronautical navigation systems

NSP Terms of Reference Objectives (ANC-President Memo, 12 December 2014)

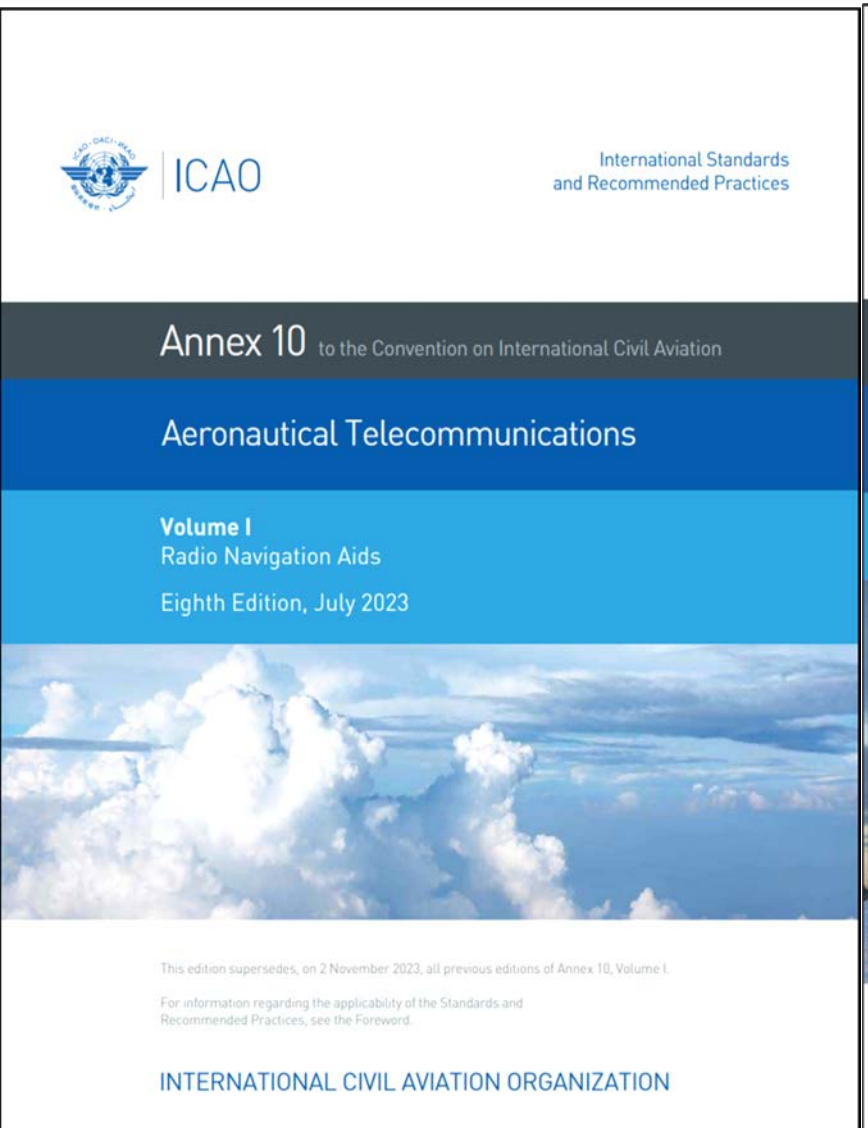
1. Develop and update strategies and plans for global navigation harmonization outlined in the Global Air Navigation Plan;
2. Monitor the development and implementation of aeronautical navigation systems and facilities in order to facilitate worldwide coordination of implementation;
3. Develop, as required, Standards and Recommended Practices (SARPs), Procedures for Air Navigation Services (PANS) and guidance material relating to:
   a. evolution of GNSS core constellation, including the introduction of new constellations and the modernization of existing ones
   b. evolution of GNSS augmentation systems (SBAS, GBAS, ABAS, including advanced receiver autonomous integrity monitoring);
   c. GNSS vulnerability issues, in particular with regard to RF interference issues and space weather effects, including consideration of alternative position, navigation and timing infrastructure;
   d. rationalization of the conventional navigation infrastructure;
   e. testing of radio navigation aids;
   f. maintenance of/resolution of issues with existing ICAO provisions for navigation systems.

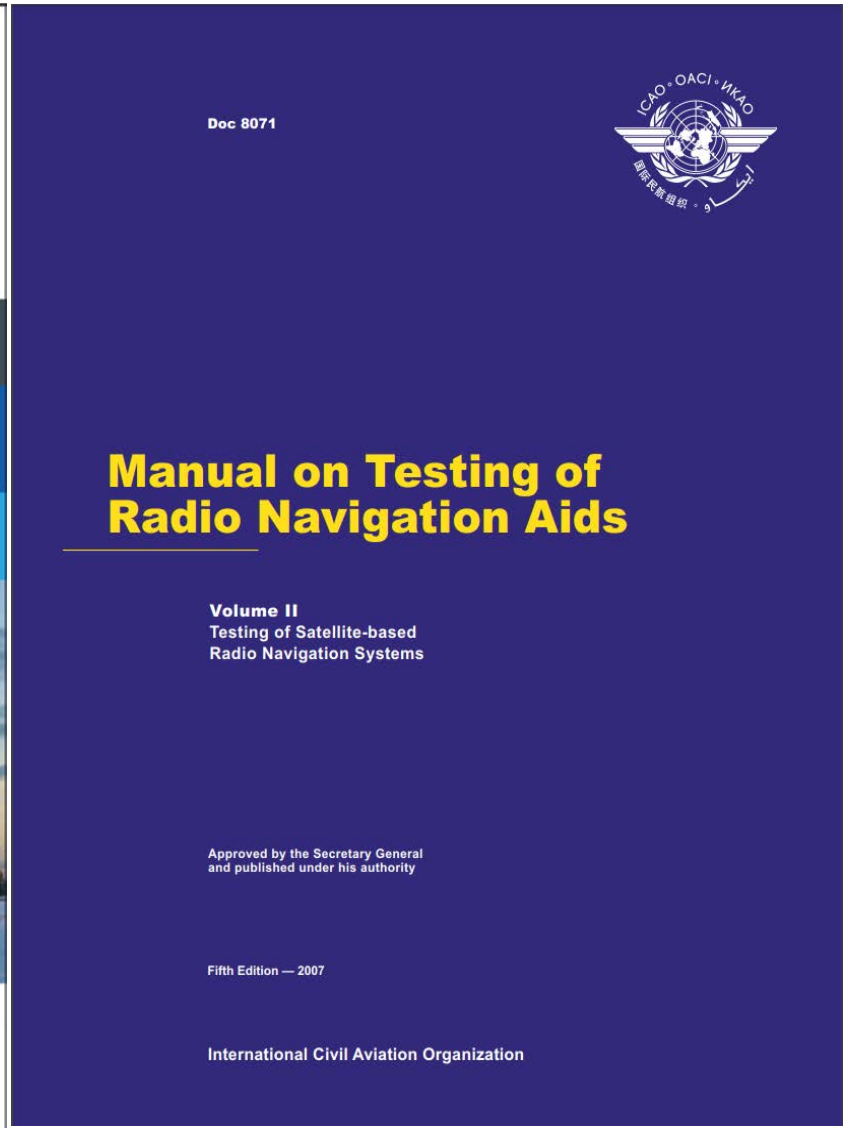
Navigation Systems Panel Structure



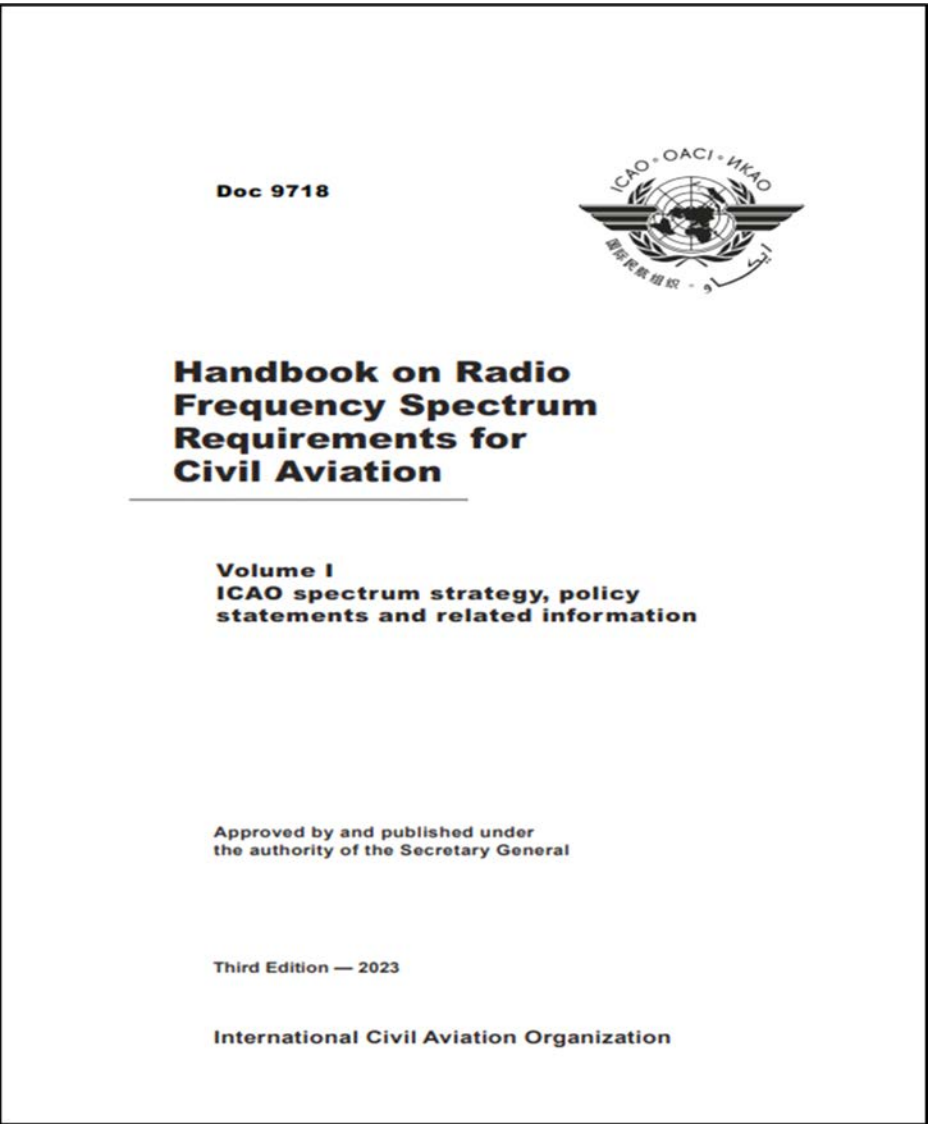
NSP Member States & Observers			NSP Member Organizations
Australia	Italy	South Africa	ICAO Secretariat
Brazil	Japan	Spain	ACI (Airports Council International)
Canada	Netherlands	Switzerland	ASECNA (Agency for Safety of Air Navigation in Africa & Madagascar)
China	Russian Federation	Turkey	European Commission
France	Saudi Arabia	United Kingdom	EUROCONTROL
Germany	Singapore	United States	IATA (International Air Transport Association)
Hungary			ICASC (International Committee for Airspace Standards)
India		Republic of Korea (Observer)	ICCAIA (International Coordinating Council of Aerospace Industries)

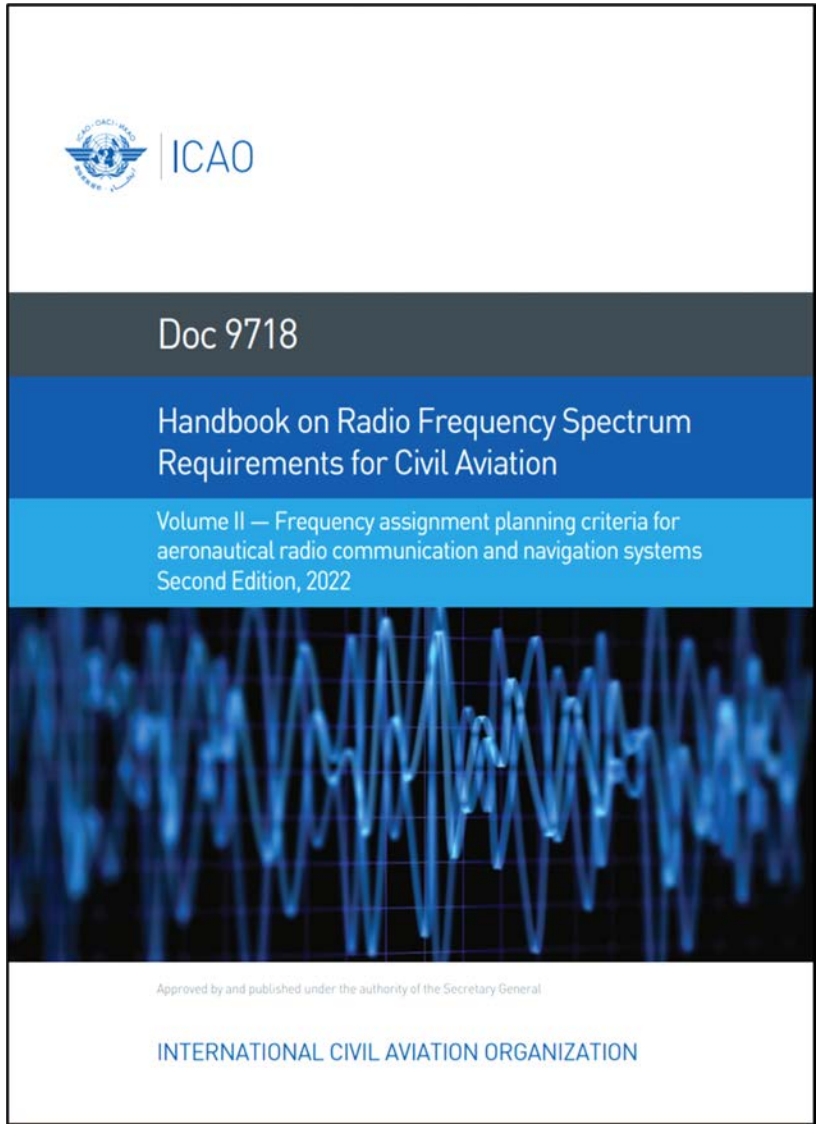
ICAO SARPs and Manuals for Radio Navigation

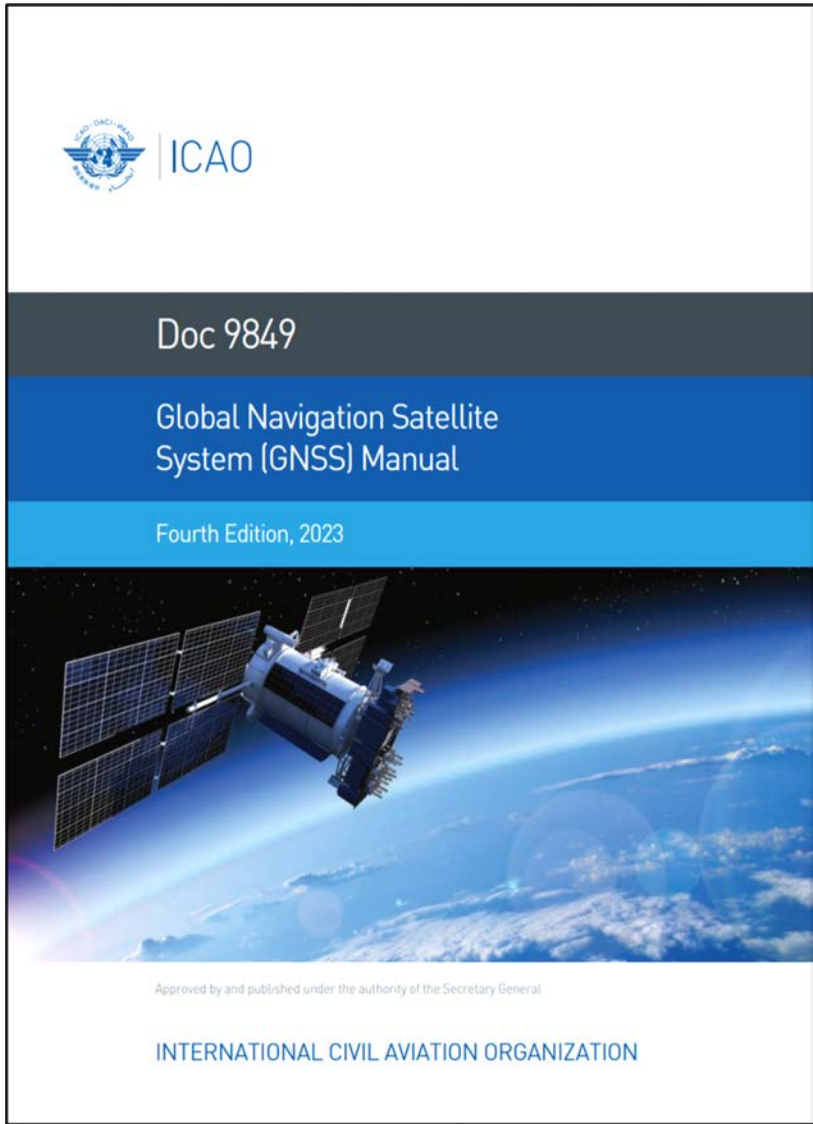




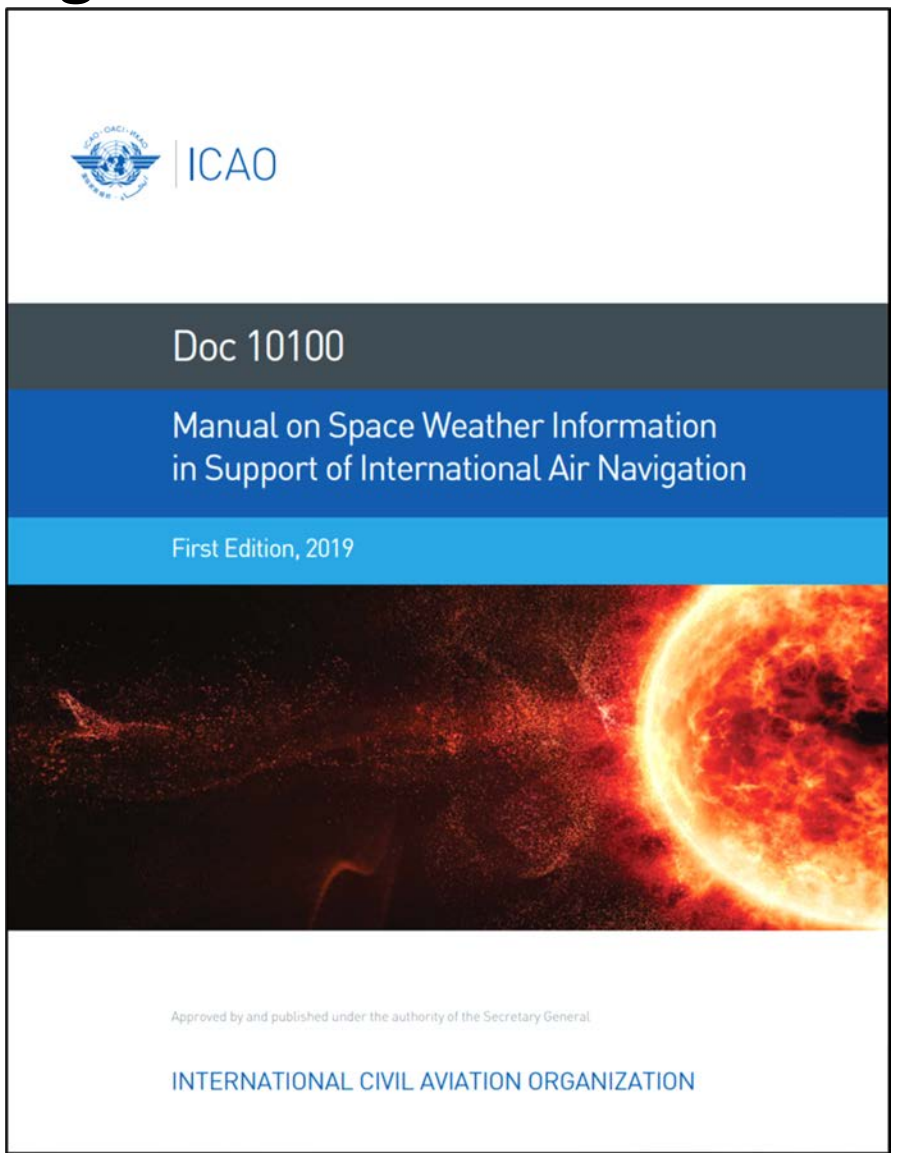
ICAO SARPs and Manuals for Radio Navigation







ICAO SARPs and Manuals for Radio Navigation



Sixth meeting of the Navigation Systems Panel (NSP/6)
2 to 13 November 2020 (Virtual)

NSP/6 Approved SARPs and Guidance material for the introduction of:

- Dual-frequency, multi-constellation (DFMC) global navigation satellite system (GNSS)
- Added provisions for additional operational frequencies for:
  - Global Positioning System (GPS)
  - GLObal Navigation Satellite System (GLONASS) and
  - Satellite-Based Augmentation System (SBAS),
- Introduced provisions for:
  - The BeiDou Navigation Satellite System (BDS) and
  - The Galileo system, and
  - Ionospheric gradient mitigation for the ground-based augmentation system (GBAS)
- The ICAO Council approved Amendment 93 to Annex 10 on 20 Mar 2023
  - Eight Edition (current) became effective 31 July 2023 and applicable on 2 November 2023

Seventh meeting of the Navigation Systems Panel (NSP/7) 9 to 19 January 2023 (in Montreal)

- Plenary and 5 Working Groups: 128 Participates from 16 States and 7 International Organizations; 49 Working Papers, 30 Information Papers and 47 Flimsies
- Panel completed & recommended for ANC and Council approval:

  2/1 Amendment to Annex 10, Volume I – Global Positioning System (GPS) update

  2/2 Amendment to Annex 10, Volume I – Galileo system update

  2/3 Amendment to Annex 10, Volume I – UTC standard identifier change

  2/4 Amendment to Annex 10, Volume I – L1 SBAS

  2/5 Amendment to Annex 10, Volume I – Advanced receiver autonomous integrity monitoring (ARAIM)

  2/6 Fourth edition of GNSS Manual (Doc 9849)

  3/1 Amendment to Annex 10, Volume I – GBAS Add'l guidance on tropospheric parameters

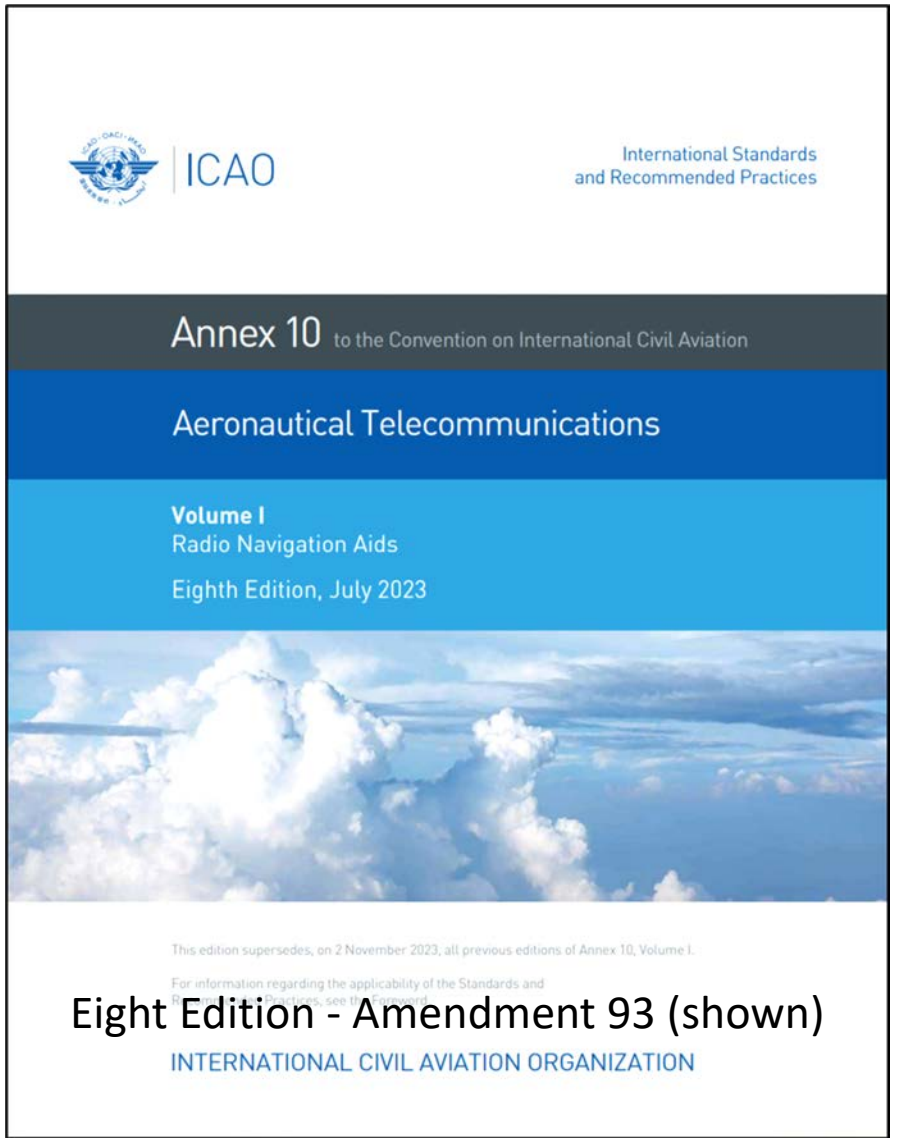
  4/1 Amendment to Annex 10, Volume I – Coverage requirements for DME not associated with VOR, ILS or MLS

  6/1 Amendment to Annex 10, Volume I – Frequency assignment planning for ILS, VOR, DME and GBAS

  6/2: Amendment to Annex 10, Volume 5 – Frequency utilization for ILS, VOR, DME and GBAS

Pending ICAO Annex 10 Ninth Edition (Amendment 94)

- NSP/7 Recommended for Approval, 19 January 2023
- ANC Recommended for Approval, September 2023
- ICAO State Letter 2023/67 sent 31 October 2023
  - Comments requested by 30 April 2024
- Amendment 94 applicability: 27 November 2025



Eight Edition - Amendment 93 (shown)

NSP Continuing Activities (Job Cards)

NSP002: GNSS Evolution – Multi-constellation

NSP003: GNSS Evolution – SBAS

NSP004: GNSS Evolution – ARAIM

NSP005: GNSS Evolution – GBAS

NSP006: GNSS Radio Frequency Interference

NSP007: Mitigation of Space Weather Effects

NSP009: Alternative Position Navigation and Timing (APNT)

Current NSP Activities (ANC Job Card Tasks for GNSS and SBAS)

- Update Annex 10, Volume I & GNSS Manual for GNSS providers':
  - Service performance standard updates
  - Regular performance assessment, and
  - Notification of events that may affect the service

  Target Q2 2024 for Mar 2026 applicability (GNSS Manual)
  Target Q2 2024 for Nov 2026 applicability (Annex 10, Volume I)

- Update Annex 10, Volume I to add optional SBAS authentication feature

  Target Q4 2026 for Nov 2029 applicability

- ARAIM Service Type B Vertical Advanced Receiver Autonomous Integrity Monitoring (V-ARAIM) Standards development
  - Operational Concept: Target Q4 2025 for Dec 2025 applicability
  - Basic Performance requirements: Target Q4 2026 for Dec 2026 applicability
  - Baseline Development Standard to support validation: Target Q4 2028 for Dec 2028 applicability

  Annex 10, Volume I Standards for ARAIM Type B (V-ARAIM)
  Target Q4 2030 for Nov 2032 applicability

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Current NSP Activities (ANC Job Card Tasks for GBAS)

ConOps/ Development Standard

- Develop GBAS DFMC concept and architecture definition
  Target Q4 2024 for Dec 2024 applicability
- Baseline development Standard to Annex 10 Vol. I to support validation
  Target Q4 2024 for Dec 2024 applicability

- Update to GNSS Manual to allow GBAS support via multiple constellations and frequencies
  Target Q4 2030 for Mar 2033 applicability

- Update to Annex 10, Volume I to add standards to support GBAS via multiple constellations and frequencies
  Target Q4 2030 for Nov 2033 applicability

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Current NSP Activities (ANC Job Card Tasks for GBAS and RFI)

Actions/ Recommend

- Provide recommendations to FSMP concerning change requests to existing ITUR recommendations and reports to relevant ITU-R groups
  Compete Q1 2023 for Mar 2023 applicability
- Develop a knowledge database on GNSS RFI, including typical cases
  Compete Q4 2023 for Nov 2024 applicability

ConOps

- Develop a concept of operations for next generation equipment functions to improve navigation service robustness (and resiliency) in the presence of Radio Frequency Interference (RFI) to GNSS
  Complete Q4 2023 for Nov 2024 applicability

- Update Manual on Testing Navaids (Doc 8071) guidance on detection, classification, localisation and resolution (including mitigation) of GNSS RFI
  Target Q4 2025 for June 2026 applicability
- Update GNSS Manual (Doc 9849) guidance on the detection, reporting, and resolution of GNSS RFI
  Target Q4 2025 for June 2026 applicability

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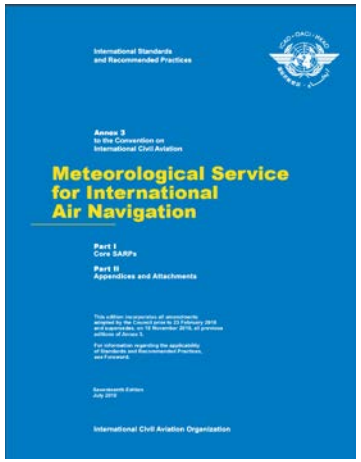
Current NSP Activities (ANC Job Card Tasks: Other Panel Support)



- Provide feedback to the ICAO Meteorological Panel on the space weather provisions in Annex 3, for consideration in next Annex 3 Amendment development

  Target Q2 2024 for Jun 2024 applicability

- Contribute to the update of the Manual on Space Weather Information for International Air Navigation (Doc 10100),

  And to the development of the related operational handbook

  Target Q2 2024 for Jun 2024 applicability

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Current NSP Activities (ANC Job Card Tasks APNT)

Report on APNT

- Report on Alternative (i.e., Complementary) Position Navigation and Timing (APNT / CPNT), including consideration of the feasibility of a long-term replacement or enhancement of DME as the main APNT/CPNT system

  Target Q4 2024 for Dec 2024 applicability

- Update Annex 10, Volume I to amend DME and other provisions as necessary to optimize APNT / CPNT functions while preparing for an efficient transition

  Target Q4 2023 for Nov 2026 applicability

NSP also provides guidance in support of other ICAO expert groups, as appropriate, to maintain safe and efficient operations when GNSS use is unavailable

ICAO 41st Assembly Resolution AR41-8C (excerpts)

Ensuring the resilience of ICAO CNS/ATM systems and services

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 disruptions or environments where false or deceptive signals are present***

Recognizing that both the ***aircraft on-board and ground infrastructure . . . needs to be adapted to include . . . interference detection, mitigation and reporting functions***

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***

ICAO 41st Assembly Resolution AR41-8C Recommendations

Recommends States:

- Transition towards optimised, **secure** CNS systems based on **complementary** integration of **suitable and independent** aircraft capabilities, satellite **and ground-based infrastructure** which maximise resiliency and robustness to any type of interference (or other disruptions)
- Need to develop technical and operational mitigations and training to best achieve resiliency, robustness, and responsible use of PNT

GNSS – What has changed?

Areas of Change	2000 – 2020	Now
Aviation GNSS Use	Growing GNSS PNT Use	GNSS Dependence is Dominate
Conventional Navigation	Decreasing NAVAIDs and Procedures	Significant Fewer NAVADs and Procedures Pilot Training Challenges
Interference & Jamming (Unintentional)	GNSS Simulator Misuse/Malfunction Personal Privacy Devices (PPD) Software Defined Radios (SDR) Space Weather Events	Decreasing Cost/Increasing Availability Increasing Use with typically limited effects Less than 100 Euros/ Impacts Unknown Degraded SBAS now; 2025 is Solar Maximum Next “Carrington” or “Miyake” event?
Jamming (Intentional)	Primarily Government Test Events Unaware Institutions/Individuals	Multiple Concurrent Daily Events Globally
Spoofing (unintentional)	Improperly Installed/Malfunctioning Re-radiators/Repeaters	Routine Aircraft Impacts Counter UAS (Multi-GNSS) Proliferating
Spoofing (Intentional)	Growing Maritime and other events	Events recorded Globally Currently Greatest Effects near Conflict Areas

Potential Considerations for Future Work

- Resilient, Robust and Responsible provision (and use) of positioning, navigation and timing (PNT) services and capabilities require:
  - Well-engineered, complementary provision of “authenticated” PNT services
  - Well-architected use of PNT (i.e., integrations) across all aircraft communication, navigation, surveillance, safety, and other aircraft specific applications
  - PNT Resiliency for ATC (and all other aviation infrastructure--especially use of time)
- GNSS Only (i.e., Sole-means) is now a significant safety, security, and economic risk
- In conjunction with introduction of next generation, more capable (DFMC) GNSS receivers and antenna
  - Reassess rationalization guidance and goals for conventional navigation and surveillance (i.e., Radar) infrastructure
- Need improved pilot and aircraft automation (e.g., Flight Management System) training/capabilities for situational awareness and reasonability cross checks

NSP Next Meetings

13 – 24 May 2024	Montreal	NSP Joint Working Groups (JWGs)/12
11 - 22 November 2024	Montreal	NSP Joint Working Groups (JWGs)/13 (or potential NSP/8) TBC
Spring 2025	TBD	
Fall 2025	TBD	

NSP will continue to serve ICAO by:

- Developing and updating strategies and plans for global navigation harmonization outlined in the Global Air Navigation Plan
- Monitoring the development and implementation of aeronautical navigation systems and facilities in order to facilitate worldwide coordination of implementation
- Developing, as required, Standards and Recommended Practices (SARPs), Procedures for Air Navigation Services (PANS) and guidance material relating to:
  - Evolution & modernization of the GNSS core constellations: GPS, GLONASS, Galileo, & BeiDou
  - Evolution of GNSS augmentation systems: SBAS, GBAS, & ABAS (including advanced receiver autonomous integrity monitoring)
  - Addressing GNSS vulnerability, in particular with regards to RF interference issues and space weather effects, including consideration of alternative (complementary) position, navigation and timing infrastructure
  - Rationalization of conventional navigation infrastructure
  - Testing of radio navigation aids
  - Maintenance and resolution of issues for existing ICAO provisions for navigation systems

Thank You!

ICAO