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ICG Experts Meeting

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ICAO Global Provisions and Regional Strategy for the Introduction of GNSS Services in Africa-Indian Ocean (AFI) Region

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OUTLINE



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- **ICAO global provisions related to GNSS**
- **ICAO regional provisions and Strategy for the introduction of GNSS services in the ICAO Africa-Indian Ocean (AFI) Region**
- **Conclusions**



About ICAO

- **International Civil Aviation Organization (ICAO)**
 - UN specialized agency created in 1944
 - Result of the Convention on International Civil Aviation (Chicago Convention)
 - 191 Member States
 - Develops international Standards and Recommended Practices (SARPs) which are then used by States when they develop their legally-binding national Civil Aviation Regulations (CARs)
 - Currently over 10,000 SARPs reflected in the 19 Annexes to the Chicago Convention



Chicago Convention



Article 28

Air navigation facilities and standard systems

Each contracting State undertakes, so far as it may find practicable, to:

- a) Provide, in its territory, airports, radio services, meteorological services and other air navigation facilities to facilitate international air navigation, in accordance with the standards and practices recommended or established from time to time, pursuant to this Convention;



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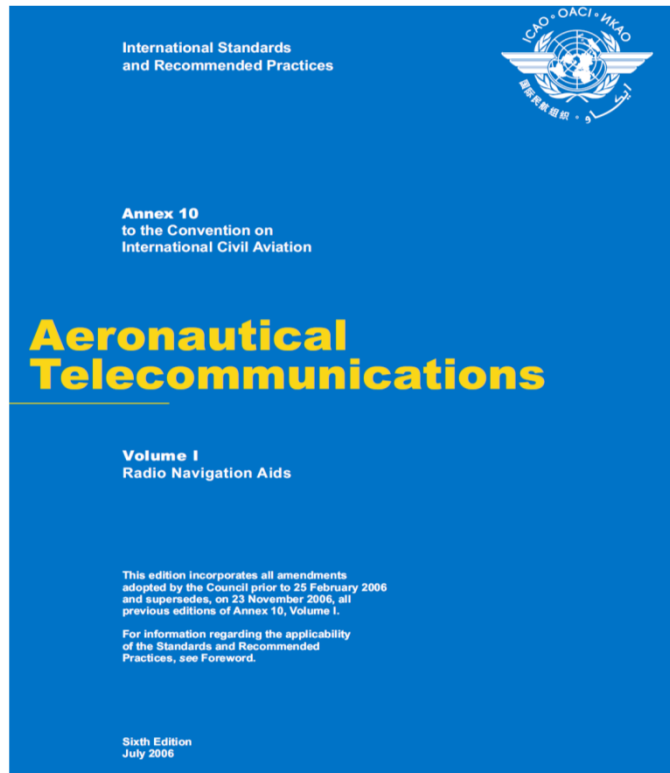
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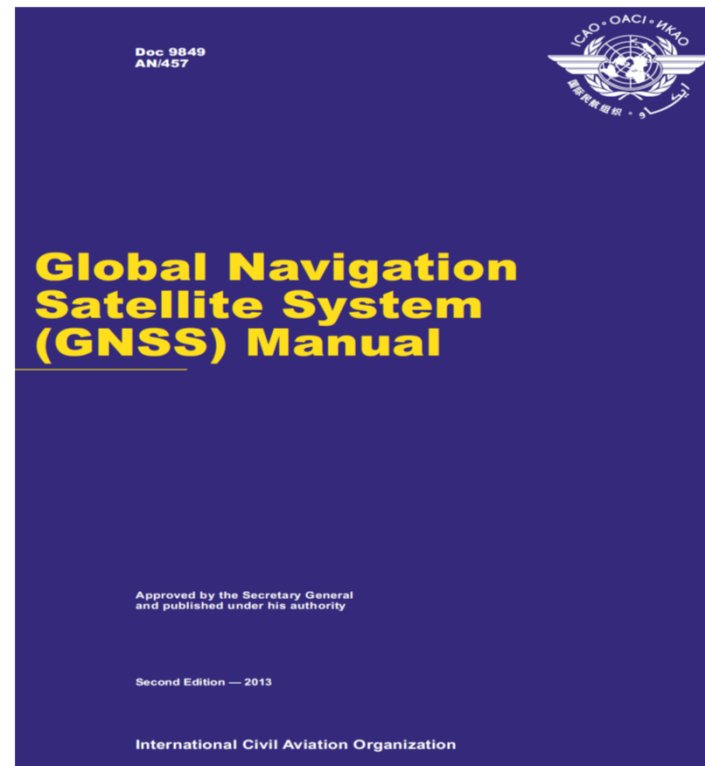


Global Provisions

Annex 10, Volume I



GNSS Manual





GNSS

- **The ICAO definition:**
 - “**GNSS**. A worldwide position and time determination system that includes one or more satellite constellations, aircraft receivers and system integrity monitoring, augmented as necessary to support the required navigation performance for the intended operation.” [from ICAO Annex 10, Volume I]
- **The practical foundation:**
 - 1994/1996: US and Russia offer to ICAO to provide GPS (Global Positioning System)/GLONASS (GLOBal NAVigation Satellite System) service for the foreseeable future on a continuous worldwide basis and free of direct user fees



ICAO policy on GNSS

- **1994**: **Statement of ICAO policy on CNS/ATM systems implementation and operation approved by the ICAO Council:**
 - *“GNSS should be implemented as an evolutionary progression from existing global navigation satellite systems, including the United States’ GPS and the Russian Federation’s GLONASS, towards an integrated GNSS over which Contracting States exercise a sufficient level control on aspects related to its use by civil aviation. ICAO shall continue to explore, in consultation with Contracting States, airspace users and service providers, the feasibility of achieving a civil, internationally controlled GNSS”*
- **1998**: **Assembly resolutions A32-19 (“Charter on the Rights and Obligations of States Relating to GNSS Services”) and A32-20 (“Development and elaboration of an appropriate long-term legal framework to govern the implementation of GNSS”)**

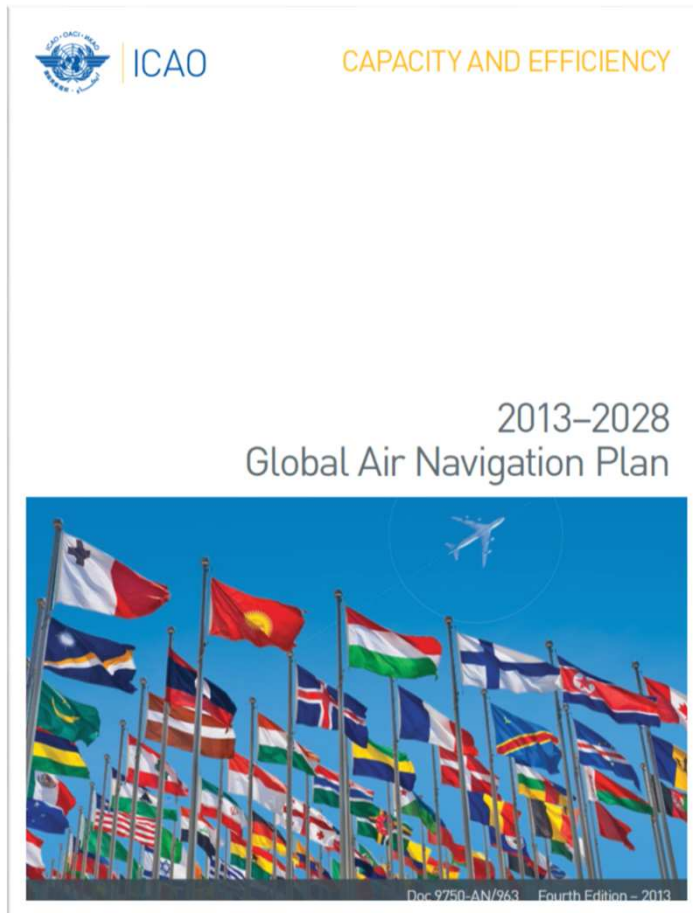


GNSS Manual

- The **ICAO Charter on the Rights and Obligations of States Relating to GNSS Services** highlights the principles that shall apply in the implementation and operation of GNSS, including: the primacy of safety; non-discriminatory access to GNSS services; State sovereignty; the obligation of provider States to ensure reliability of services; and cooperation and mutual assistance in global planning.
- The availability of multiple constellations broadcasting on multiple frequencies will make GNSS more robust and will allow service expansion with increased benefits after 2020 when systems and avionics are available.
- In the meantime, ANS providers can work with aircraft operators to expand GNSS-based services and benefits while planning next generation services.



GNSS Manual



When planning to implement GNSS-based operations, States are encouraged

- to refer to the **GANP** and relevant **ASBUs**,
- to comply with ICAO provisions; and
- to take advantage of the expertise and information available at the ICAO **planning and implementation regional groups (PIRGs)**.



Current ICAO Directives on GNSS Implementation

12th Air Navigation Conference (2012) - Recommendations

- Recommendation 6/5 – ICAO work programme to support global navigation satellite system evolution
- Recommendation 6/6 – Use of multiple constellations
- Recommendation 6/7 – Assistance to States in mitigating global navigation satellite system vulnerabilities
- Recommendation 6/8 – Planning for mitigation of global navigation satellite system (GNSS) vulnerabilities
- Recommendation 6/9 – Ionosphere and space weather information for future global navigation satellite system implementation.



Current ICAO Directives on GNSS Implementation

ICAO Assembly Resolution A37/11

- Implementation of performance – based navigation (PBN) approaches with vertical guidance (APV) with
 - satellite-based augmentation system (SBAS) or
 - barometric vertical navigation (Baro-VNAV).



GNSS elements: the ICAO GNSS Standards Menu

| System | ICAO Standard? | Infrastructure in place today? | Aircraft provisions today? | In operational use by aviation today? |
|-----------------|----------------|--|----------------------------|---------------------------------------|
| GPS L1 | Yes | Yes | Yes | Yes, globally |
| GLONASS | Yes | Yes | Russia | Russia |
| SBAS L1 | Yes | Regional support (WAAS, MSAS, EGNOS, GAGAN, SDCM...) | Yes | Yes, regionally |
| GBAS Cat I | Yes | Local support (individual airports) | Yes | Yes, locally |
| GBAS Cat II/III | 2017/2018 | No | Advanced development | No |
| GPS L5 | 2018+ | Partial (8 satellites) | Early development | No |
| Galileo | 2018+ | Partial (2 FOC+6) | Early development | No |
| Beidou | 2018+ | Partial | Early development | No |
| SBAS L1/L5 | 2018+ | No | Early development | No |



GNSS signal-in-space performance requirements (ICAO Annex 10, Volume I)

- **Accuracy** – The difference between the estimated and actual aircraft position
- **Integrity** – A measure of the trust which can be placed in the correctness of the information supplied by the total system. It includes the ability of the system to alert the user when the system should not be used for the intended operation (alert) within a prescribed time period (time-to-alert)
- **Continuity** – The capability of the system to perform its function without unscheduled interruptions during the intended operation
- **Availability** – The portion of time during which the system is simultaneously delivering the required accuracy, integrity and continuity



GNSS signal-in-space performance requirements (ICAO Annex 10, Volume I)

| Typical operation | Accuracy horizontal 95% (Notes 1 and 3) | Accuracy vertical 95% (Notes 1 and 3) | Integrity (Note 2) | Time-to-alert (Note 3) | Continuity (Note 4) | Availability (Note 5) |
|---|---|--|--|---------------------------|---|--------------------------|
| En-route | 3.7 km (2.0 NM) | N/A | $1 - 1 \times 10^{-7}/h$ | 5 min | $1 - 1 \times 10^{-4}/h$ to $1 - 1 \times 10^{-8}/h$ | 0.99 to 0.99999 |
| En-route, Terminal | 0.74 km (0.4 NM) | N/A | $1 - 1 \times 10^{-7}/h$ | 15 s | $1 - 1 \times 10^{-4}/h$ to $1 - 1 \times 10^{-8}/h$ | 0.99 to 0.99999 |
| Initial approach, Intermediate approach, Non-precision approach (NPA), Departure | 220 m (720 ft) | N/A | $1 - 1 \times 10^{-7}/h$ | 10 s | $1 - 1 \times 10^{-4}/h$ to $1 - 1 \times 10^{-8}/h$ | 0.99 to 0.99999 |
| Approach operations with vertical guidance (APV-I) | 16.0 m (52 ft) | 20 m (66 ft) | $1 - 2 \times 10^{-7}$ in any approach | 10 s | $1 - 8 \times 10^{-6}$ per 15 s | 0.99 to 0.99999 |
| Approach operations with vertical guidance (APV-II) | 16.0 m (52 ft) | 8.0 m (26 ft) | $1 - 2 \times 10^{-7}$ in any approach | 6 s | $1 - 8 \times 10^{-6}$ per 15 s | 0.99 to 0.99999 |
| Category I precision approach (Note 7) | 16.0 m (52 ft) | 6.0 m to 4.0 m (20 ft to 13 ft) (Note 6) | $1 - 2 \times 10^{-7}$ in any approach | 6 s | $1 - 8 \times 10^{-6}$ per 15 s | 0.99 to 0.99999 |
| <i>NOTES.—</i> [...] | | | | | | |



GNSS signal-in-space performance requirements (ICAO Annex 10, Volume I)

- **Annex 10 to the Convention on International Civil Aviation, Volume I enables Category I approach operations supported by satellite-based augmentation system (SBAS).**
- **The upper vertical alert limit (VAL) for CAT I operations has drastically been increased from 15.0 m to 35.0 m.**
- **However, a vertical alert limit greater than 10 m for a specific system design may only be used if a system-specific safety analysis has been completed.**



GNSS Evolution: Multiconstellation - Dual Frequency (MC-DF)

- **Not for now...**
- **Technically promising**
 - **Performance improvements (increased availability, better protection against interference and ionosphere effects)**
 - **Potential operational benefits**
- **Open challenges**
 - **Regulatory issues: conflicting mandates/authorizations**
 - **Human factors issues: potential additional cockpit complexity due to different mandates/authorizations**
 - **Avionics development/certification/equipage**



Strategy for GNSS introduction in the ICAO AFI Region

| | Short term 2008 – 2012 | Medium term 2013 – 2016 | Long term 2017 and beyond |
|---|--|------------------------------------|--|
| Time scale | 2008 – 2012 | 2013 – 2016 | 2017 and beyond |
| Certification | Primary for en-route Supplemental for TMA Non-precision approach (NPA) | Primary means from en route to APV | Primary means from en route to CAT-I |
| Oceanic and Remote Continental En route | Basic GNSS | Basic GNSS | Multi-constellation GNSS |
| Continental En route | Basic GNSS | Basic GNSS | Multi-constellation GNSS |
| Terminal | Basic GNSS | Basic GNSS | Multi-constellation GNSS |
| Approach and Landing | Basic GNSS with Barometric Altimetry | Basic GNSS with ABAS, SBAS* | Multi-constellation GNSS with ABAS, SBAS, GBAS CAT I (GLS) CAT II/III/ (GLS) as required |



Implementation Criteria for GNSS/SBAS

(Africa-Indian Ocean Planning and Implementation Regional Group - APIRG)

- Availability of conclusive cost-benefit analysis (APIRG Conclusion 17/29 refers)
- Full compliance with ICAO technical requirements (Standards and Recommended Practices);
- Agreement between stakeholders on pre-implementation cost-benefit analyses on case-by-case basis;
- Application of the user-pays principle across all sectors (SBAS users). National authorities shall prevent cross-subsidization of non civil aviation users of SBAS.



Impact analysis of the Implementation of GNSS/SBAS in the AFI Region (APIRG Conclusion 19/29)

That, in order to enable States to make informed decision and to facilitate dialogue among stakeholders, concerning the implementation of GNSS satellite-based augmentation system (SBAS) in the AFI Region, the ICAO Regional Offices should facilitate the search for the funding of an impact analysis related to SBAS, that covers operational, technical, environmental and economic aspects of this GNSS augmentation system.

General Guidelines on the Establishment and Provision of a Multinational Air Navigation Facility/Service (Doc 9161)

Definition

- **A multinational ICAO air navigation facility/service can be defined as a facility or service included in an ICAO Regional Air Navigation Plan for the purpose of serving international air navigation in airspace extending beyond the airspace serviced by a single State in accordance with that regional air navigation plan.**

- **AFI SBAS Concept**
 - **Multinational facility/service**



Conclusions

- **The AFI GNSS Strategy defined by APIRG includes SBAS as candidate technology to support PBN (as per ICAO Global Air Navigation Plan)**
- **SBAS falls under the definition of a multinational facility/service (ICAO Doc 9161)**
 - Guidelines may be considered
- **Need for regional coordination involving ICAO, AFCAC/AUC, ASECNA, RECs, Development Partners, Users and other stakeholders in order to:**
 - ensure harmonization and integration of regional programmes and initiatives pertaining to GNSS;
 - facilitate States' Decision-Making (e.g. CBA, safety assessment, etc.)
 - coordinate GNSS System Design/Architecture and Implementation in the AFI Region and related institutional issues
 - ensure States' ownership of coordinated programmes



Conclusions

The way forward

- Embrace early benefits from Basic GNSS (aircraft based augmentation system -ABAS) implementation
- Recognize the regional SBAS infrastructure available (and expanding) today, and the local GBAS developments taking place around the world
- Be responsive to air operator needs and aircraft fleet capabilities
- Coordinate regional implementation of GNSS through ICAO regional structure
- Address GNSS open issues on the basis of specific cost/benefit considerations as opposed to rigid across-the-board positions
- Monitor future developments of basic GNSS constellations for >2025 fruition



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