



Sixth Meeting of CNS/MET Sub-Group of APANPIRG

Bangkok, Thailand, 15 – 19 July 2002

Agenda Item 6:

Review:

- a) **Strategy for the provision of Precision Approach and Landing Guidance Systems**
- b) **GNSS strategy**
- c) **GNSS implementation**
- d) **GPS measurement campaign**

c) GNSS Implementation

**MANUAL OF TESTING OF RADIO NAVIGATION AIDS
VOL. II, TESTING OF SATELLITE-BASED RADIO NAVIGATIONS SYSTEMS**

(Presented by the Secretariat)

SUMMARY

This paper provides information on the availability of Guidance Material on testing of Satellite-based Radio Navigation Aids and the materials for SBAS and GBAS which are under development.

1. INTRODUCTION

1.1 The Fifth Meeting of the Testing of Radio Navigation Aids Study Group (TRNA SG/5) was held in Montreal, Canada from 18 to 22 March 2002. The objective of the meeting was to review of draft material for Doc 8071, Manual on Testing of Radio Navigation Aids, Volume II- Testing of satellite-based and ground-based augmentation systems (SBAS and GBAS) contained in the draft Chapters 3 and 4 of the document. The Sixth Meeting of the TRNASG will be held in 2003 to complete these two Chapters.

2. DISCUSSION

2.1 The new edition of Volume II of Doc 8071 provided in Attachment to this paper was developed by the Testing of Radio Navigation Study Group (TRNSG) to provide guidance on Testing of Satellite-based Radio Navigation Systems. This edition of Volume II contains guidance on testing of non-precision approach (NPA) procedures using aircraft-based augmentation system (ABAS).

2.2 Chapters 3 and 4 of this document, which will provide guidance on testing of satellite-based of augmentation system (SBAS) and ground-based augmentation system (GBAS), are still under development and will be included in the next edition of Volume II.

3. ACTION BY THE MEETING

3.1 The meeting is expected to note the available Guidance Material provided in the Attachment for the Flight Inspection of GNSS.

DRAFT

(Distribution of this draft document presents an opportunity for participants of the 12th IFIS to comment on the draft. The comments can be sent to the Secretary of TRNSG by e-mail at <viatsouk@icao.int> or by facsimile at (514) 954-6759 not later than 1 July 2002.)

MANUAL ON TESTING OF RADIO NAVIGATION AIDS

VOLUME II

TESTING OF SATELLITE-BASED RADIO NAVIGATION SYSTEMS

Fourth Edition — 2002

INTERNATIONAL CIVIL AVIATION ORGANIZATION

Foreword

The need for uniform navigational guidance signals and consistent system performance for radio navigation aids used in the international aeronautical services has been recognized as an important adjunct to safety and regularity in civil aviation. ICAO continuing air navigation policies, and associated practices of the Organization in their part concerning ground and flight testing of radio navigation aids, call attention to this need and encourage improvements in radio navigation ground equipment, including associated testing and monitoring facilities, with the view to minimizing, to the extent practicable, the more demanding requirements of flight testing. Annex 10, Volume I, 2.7, provides an international Standard on the ground and flight testing of radio navigation aids.

This new edition of Volume II of Doc 8071 was developed by the Testing of Radio Navigation Study Group (TRNSG) to provide guidance on Testing of Satellite-based Radio Navigation Systems. This edition of Volume II contains guidance on testing of non-precision approach (NPA) procedures using aircraft-based augmentation system (ABAS). Chapters 3 and 4 of this document, which will provide guidance on testing of satellite-based of augmentation system (SBAS) and ground-based augmentation system (GBAS), are still under development and will be included in the next edition of Volume II.

The purpose of this document is to provide general guidance on the extent of testing and inspection of GNSS-based procedures. The guidance is representative of practices existing in a number of States.

Comments on this volume would be appreciated from States and other parties outside ICAO concerned with satellite radio navigation systems development and provision of services. Comments, if any, should be addressed to:

The Secretary General
International Civil Aviation Organization
999 University Street
Montreal, Quebec
Canada H3C 5H7

Chapter 1

GENERAL

1.1 INTRODUCTION

1.1.1 Annex 10, Volume I, Chapter 2, 2.7 states, “radio navigation aids of the types covered by the specifications in Chapter 3 (Annex 10, Volume I) and available for use by aircraft engaged in international air traffic shall be the subject of periodic ground and flight tests”.

1.1.2 Volume 2 of the *Manual on Testing of Radio Navigation Aids* (Doc 8071, Fourth edition) addresses Global Navigation Satellite System (GNSS). General description of GNSS elements is contained in Attachment 4 to Chapter 1. This document contains “guidance material” only. The tests and procedures outlined do not have the status of Standards or Recommended Practices (SARPs) except for identified quotations from Annex 10.

1.2 PURPOSE OF THE DOCUMENT

This document is intended to provide general guidance on the testing and inspection to be carried out to ensure that GNSS procedures, using the SARPs specified in Annex 10, Volume I, Chapter 3.3.7, are appropriate for aviation use.

1.3 SCOPE OF THE DOCUMENT

1.3.1 This document describes the ground and flight testing to be accomplished for a specific radio navigation aid. Volume 2 addresses GNSS systems, and while maintaining the same format as Volume I it adopts a change in philosophy to focus on total system performance rather than concentrating on detailed measurement of individual parameters.

1.3.2 Information is provided on measurement practices and special test equipment; however, it is not intended to recommend certain models of equipment, but rather to provide general information relative to the systems under consideration.

1.3.3 System testing is addressed in this document in general terms. System testing is normally done as

part of design and development activities, prior to volume production and individual site installations. System testing includes design qualification testing, operational test and evaluation, and “shakedown” tests.

1.3.4 In this document, the terms “testing” and “inspection” have the following meanings:

- *Testing: A specific measurement or check of facility performance that may form a part of an inspection when integrated with other tests.*
- *Inspection: A series of tests carried out by a State authority or an organization as authorized by the State to establish the operational classification of the facility.*

1.3.5 GNSS navigation relies on real-time calculation of satellite and augmentation system information to determine position relative to the World Geodetic System – 1984 (WGS-84) geodetic reference datum. Testing is accomplished by dividing the GNSS architecture into the space-to-earth signals, from core satellite constellation(s), augmentation information and signals and procedure definition, including the integrity of the navigation database.

1.3.6 Operation of the core satellite constellation elements, such as GPS or GLONASS, is the responsibility of States or the designated authority providing the service. In general these elements are not tested as part of the ground or flight testing of a particular procedure. The exception is the confirmation that the spectrum used is free from harmful interference. Throughout the tests described, accuracy of the space-to-earth signals is not measured.

1.3.7 The augmentation systems external to the aircraft, such as satellited-based augmentation system (SBAS) and ground-based augmentation system (GBAS), are evaluated in accordance with this manual*. Where particular performance is required by SARPs, appropriate ground and flight tests are

* Guidance material on testing of SBAS and GBAS-based procedures for Chapters 3 and 4 of this Volume is under development.

described. Aircraft-based augmentation system (ABAS) is considered to be an airworthiness requirement and outside the scope of this volume.

1.3.8 The design of procedures requires the coding of geodetic information in a form useable by the on-board navigation system. Tests are described for the assessment of procedures for their data accuracy and operational suitability. Verification of data is limited to point of publication in the State's Aeronautical Information Publication (AIP) and does not take account of errors introduced by data packaging and distribution organizations. Data verification does include systems which transmit the data set as part of an augmentation system.

1.4 GROUND VERSUS FLIGHT TESTING/INSPECTION

General

1.4.1 The considerations for ground and flight testing/inspection as given in Doc 8071, Volume I, Chapter 1, paragraph 1.4, are also relevant for all applications of GNSS.

Testing objective

1.4.2 Ground and flight testing/inspection should serve to assess the consistency of the flight procedure as well as any influences which may lead to a local degradation in GNSS availability at the location of the inspection (e.g. interference). Ground and flight testing/inspection also assesses the performance of any local/regional GNSS augmentations.

GNSS analysis

1.4.3 When a State begins the introduction of GNSS flight procedures, an analysis should be performed of the capability of the particular GNSS architecture to provide the required performance to support the intended procedures (Annex 10, Volume I, Chapter 3, 3.7.2.4 refers). It is widely accepted that the GPS constellation of 24 satellites delivers availability of more than 99% for the en-route operations, and of more than 97% for non-precision approach (NPA) procedures, in most parts of the world. However, this may not be true for the particular State and different GNSS core constellations. As an outcome of such analysis, the State may decide whether the safe use of GNSS requires any type of GNSS performance prediction as part of the flight preparation.

Importance of geodetic survey

1.4.4 The position information provided by GNSS is expressed in terms of the World Geodetic System – 1984 (WGS-84) geodetic reference datum. By contrast with conventional navigation systems, GNSS navigation delivers an aircraft to a point in space defined in a database, and not to a terrestrial fixed point such as an antenna location. This change in concept places a high demand on the integrity of all survey data used in preparation of the flight procedure and in the onboard navigation system. It is mandatory that a State authorizing GNSS flight procedures maintains an appropriate quality assurance system covering all domains of data collection (survey), processing, and publication. SARPs applicable to WGS-84 and aeronautical data are provided in Annexes 4, 11, 14 and 15.

GNSS monitoring

1.4.5 A State providing GNSS services for aviation should continuously perform a suitable monitoring and assessment of the GNSS signal in space (Annex 10, Volume I, Chapter 2, 2.4.3 refers). Such activity can detect any long-term trends which may affect GNSS performance within the airspace where GNSS-based operations are authorized by of this State. There is no requirement to perform such a determination for any location in particular. The activities may be performed in the following domains:

Coordinate survey stability

1.4.5.1 While some parts of the world may experience a very stable relationship between their local WGS-84 coordinates and the core GNSS constellations, other parts may experience a physical movement relative to an earth-centred, earth-fixed reference system. The magnitude of such effects should be assessed prior to commencing GNSS operations. Appropriate mitigation schemes (e.g. periodic measurement campaigns, extrapolation computations) may be considered to limit the influence of such effects. It should be noted that the possibly small annual magnitude of coordinate shifts may build up to produce larger effects over longer periods of time.

GNSS availability

1.4.5.2 Subsequent to establishing the overall availability of GNSS in a particular State (as outlined in 1.4.3), proper means should be in place to assess the long-term evolution of a satellite system's availability to support GNSS operations. The purpose of this analysis is to determine whether any change has

occurred to the conditions considered acceptable when the use of GNSS was originally authorized by this State, and to provide an indication whenever GNSS does not perform within the limits specified in the SARPs.

Interference

1.4.5.3 A traceability record should be maintained of all incidents involving interference, from both in-band and out-of-band sources, with the GNSS frequencies in use in a particular State. This record may be derived in several ways, including incident reports from local ground and/or flight inspections, use of special receivers for long-term monitoring of any frequency interference, or by incident reports from the airspace users.

Record keeping

1.4.6 The data derived from ground and flight test/inspection should be kept for a period of time as described in Appendix 2 of Chapter 1, Volume I of Doc. 8071. The data derived from monitoring (paragraph 1.4.5) should be kept for a time period appropriate to assess the influence of long-term effects. Data pertinent to accident and incident investigations should be retained until they are no longer required

Availability prediction software

1.4.7 Software with an almanac applicable to the time of the flight test should be used to verify that minimum satellite geometry requirements are met for the full duration of the flight test. This will prevent unnecessary flight test attempts when the geometry does not support accuracy requirements. Such a prediction will also allow a clearer distinction between availability alarms triggered by insufficient satellite coverage and those caused by interference.

GPS Selective Availability

1.4.8 GNSS (GPS) specifications currently in Annex 10 do not account for the termination, as of 1 May 2000, of the selective availability (SA) feature of GPS. Improvements resulting from the SA termination will be incorporated in GNSS SARPs subject to their validation. It should be also noted that basic GPS receivers employing receiver autonomous integrity monitoring (RAIM), designed to operate with “SA-on” cannot take advantage of improved GPS availability resulting from the SA termination.

1.5 CATEGORIES AND PRIORITIES OF TESTS AND INSPECTIONS

1.5.1 It is difficult to define requirements for intervals between various types of tests/inspections due to many associated factors specific to different States. Factors such as stability of equipment, extent of monitoring, geographical area, weather, quality of maintenance crews, standby equipment, etc., are all related. The period between tests/inspections of a new facility should be short during the early months of operation and may be extended as satisfactory experience is gained.

1.5.2 This document contains suggested schedules for each augmentation system type. The schedules should be considered (and modified, if necessary) based on the conditions relevant to each State and each site. The manufacturer's instruction manual will usually contain recommendations that may be useful in this regard. Facility testing can be considered in the following general categories.

Ground testing/inspection

1.5.3 *Site proving:* Tests carried out at proposed sites for the ground facility to prove suitability. Portable ground installations are used for this purpose.

1.5.4 *Initial proof of performance:* A complete inspection of the facility after installation and prior to commissioning to determine that the equipment meets the Standards and manufacturer's specifications.

1.5.5 *Periodic:* Regular or routine inspections carried out on a facility to determine that the equipment continues to meet the Standards and manufacturer's specifications.

1.5.6 *Special:* Tests after a failure of the facility or other circumstances that indicate special testing is required. Special tests will often result in appropriate maintenance work to restore the facility and a special flight inspection, if required.

Flight testing/inspection

1.5.7 *Site proving:* A flight test conducted at the option of the responsible Authority to determine the effects of the ground environment at the proposed location on the performance of the planned facility or procedure.

1.5.8 *Commissioning*: An extensive flight inspection to establish the validity of the procedure and augmentation signals.

1.5.9 *Periodic*: Flight inspection to confirm the validity of the procedure and augmentation signals on a regular basis.

1.5.10 *Special*: Flight inspection required to investigate suspected malfunctions, aircraft accidents, etc. It is ordinarily only necessary to test those parameters which have or might have an effect on performance during special flight inspections. It may be economically advantageous in many cases to complete the requirements for a periodic or annual inspection.

Priority of inspections

1.5.11 Flight inspections should be scheduled and conducted using a priority system. Each State's Aeronautical Authority should define a specific priority for procedures based on GNSS information, as contrasted with conventional procedures, until a general experience exists about the behavior and use of GNSS navigation. The following is a suggested grouping of priorities:

- a) *Priority 1*: Accident investigation, restoration of established facilities after unscheduled outages, and investigation of reported malfunctions.
- b) *Priority 2*: Periodic inspections, commissioning of newly installed facilities, associated instrument flight procedures, and evaluations of proposed sites for new installations.

1.6 OPERATIONAL STATUS

Facility and/or procedure status can be identified as follows:

- a) *Usable*: Available for operational use.
 - i) *Unrestricted*: Providing safe and suitable conditions conforming to established Standards within the required airspace.
 - ii) *Limited or restricted*: Providing guidance not conforming to established Standards in all respects or in all sectors of the coverage area, but safe for use within the restrictions defined. It is extremely important that no procedure or

facility which could be unsafe be classified as limited.

- b) *Unusable*: Not available for operational use, or providing unsafe or erroneous guidance, or providing signals of an unknown quality.

1.7 AUTHORITY FOR STATUS DETERMINATION

The responsibility for determining procedure and facility status rests with the appropriate State authority or the organization authorized by the State.

1.8 NOTIFICATION OF CHANGE OF STATUS

1.8.1 Notification of a change of procedure or facility status is to be done through appropriate Aeronautical Information Publications; differences from Standards are to be notified to ICAO and through NOTAMs.

1.8.2 Day-to-day changes of the status of procedures and facilities are to be promptly and efficiently advertised. A change of the status of a procedure or commissioned facility as a direct result of ground or flight inspection procedures, and resulting in a "usable" ("unrestricted", "limited", or "restricted") or "unusable" designation, should be advertised immediately by air traffic control (ATC) personnel, and promptly by a NOTAM.

1.8.3 A facility having an "unusable" status is normally removed from service and can operate only for test or troubleshooting purposes.

1.9 AIRBORNE AND GROUND TEST EQUIPMENT REQUIREMENTS

The selection and utilization of special ground or flight inspection equipment used to determine the validity of navigation information and approach procedures should minimize the uncertainty of the measurement being performed. This equipment should be periodically calibrated to ensure traceability of measurements to appropriate standards.

1.10 COORDINATION BETWEEN GROUND AND FLIGHT TEST/INSPECTION

1.10.1 Comparison of the results obtained during successive ground and flight tests/inspections can determine the extent of the degradation of the performance of the procedure or facility. These results can also be used to determine the choice of the periodicity of the flight test/inspection.

1.10.2 Flight test/inspection may involve a coordinated effort with ground specialists making adjustments or participating in the flight test/inspection. Efficient two-way communications should be established between ground and air. An additional VHF transceiver is often installed in the aircraft and a portable unit employed at the facility to provide this without interfering with the normal aircraft communications with air traffic control.

1.10.3. After comparing the results obtained during successive ground and flight test/inspection, the flight inspector may incorporate some of them in the flight inspection report, with the purpose of providing a more detailed and controlled record of the history of the facility/procedure.

1.11 FLIGHT INSPECTION UNIT

General

1.11.1 This section should be read in conjunction with section 1.11 of Chapter 1, Volume I. Further information specific to GNSS is given in this section.

1.11.2 GNSS flight inspection differs from conventional radio navigation aid inspection in that it does not attempt to verify the accuracy of the raw signals transmitted from the satellites. It is more concerned with verification of the associated procedures and of the radio environment in which the navigation signals are received. The only exception is GBAS where the coverage of the augmentation signal is verified using similar procedures to those used for terrestrial navigation aids.

Position-fixing systems

1.11.3 For inspection of non-precision approach (NPA) procedures, an independent position fixing system is not necessary. The pilot will assess the position guidance throughout the approach and confirm that obstacle clearance is sufficient and that the guidance delivers the aircraft to a suitable position from which to complete the landing.

1.11.4 For inspection of GBAS or SBAS procedures, GNSS positioning may be used, provided that its independence can be demonstrated. For example, for code-based GBAS, a carrier-based position fixing system may be used. Alternatively, a non-GNSS based position fixing system may be used.

Flight inspection aircraft

1.11.5 The inspection aircraft should be fitted with certified GNSS aerials having known polar diagrams and gain. Consideration should be given to fitting an additional aerial on the underside of the aircraft for interference investigations.

1.11.6 For NPA inspection, a much simplified flight inspection aircraft may be used. The aircraft should be fitted with a basic GPS receiver (TSO C129), or an acceptable equivalent, and a properly installed external aerial. Temporary internal aerials are not suitable since there is no traceability of their polar diagram or gain. No other specialized equipment need be carried. In the event of this simplified inspection aircraft detecting any problems, further inspection should be made using a fully equipped aircraft.

Flight inspection crew

1.11.7 For flight inspection of GNSS precision approach procedures, the crew should be trained in all aspects of GNSS inspection. This training should include the use of appropriate position fixing systems where these are required for the inspection.

1.11.8 For NPA inspection, the crew need not be fully qualified flight inspection pilots. An NPA inspection pilot should be familiar with approach procedure inspection and should be sufficiently trained to recognize any anomalous output from the receiver which would signify the need for more detailed inspection with a fully equipped aircraft and crew.

1.11.9 A specialized navigation aid inspector is not required for NPA procedure inspection, unless any anomalies require investigation or a comprehensive inspection has been specifically requested.

1.12 ORGANIZATION AND QUALITY

Information on this topic is contained in Chapter 1 of Doc. 8071, Volume I.

1.13 ELECTROMAGNETIC INTERFERENCE

1.13.1 Attachment 3 to this Chapter provides guidance on this subject specifically for GNSS, including types of interference, possible sources, methods of detection, and mitigations which can be used to eliminate or reduce the interference effects.

1.13.2 Additional guidance is available in RTCA document DO-235, Assessment of Radio Frequency Interference Relevant to the GNSS.

1.14 SPECTRUM ANALYSIS

1.14.1 Information on this topic is contained in Attachment 3 to this chapter.

1.15 GROUND AND FLIGHT INSPECTION PERIODICITY

General

1.15.1 The determination of periodicity for ground and flight inspection should be based on a risk assessment of out-of-tolerance performance, which is not detected by the implemented monitoring system. Events which should be considered in determining the requirement for inspection include:

- a) change in procedure and/or data set;
- b) equipment failure and stability; and/or
- c) environmental changes, particularly those that may cause RF interference.

Ground testing/inspection

1.15.2 Ground-based augmentation should be inspected at commissioning, configuration change (including software changes), and at periodic intervals based on equipment reliability. In considering equipment reliability it is appropriate to consider the

influence of a sub-assembly on the integrity of the guidance information provided by the total system. For example the failure of a monitor may leave equipment in a state that will provide out-of-tolerance information in the case of a subsequent failure of the processing or transmission system. Other assembly failures may result in a reduced service volume; however, the information provided within the reduced volume is unaffected and within tolerance. For precision approach facilities, assemblies with significant influence on the integrity of provided information should be checked on a semi-annual or manufacturer's recommendation basis, whichever is more frequent.

Flight testing/inspection

1.15.3 Flight tests should be completed prior to commissioning, at the implementation of system configuration changes including procedure changes, and on a periodic basis based on environment changes. Flight tests are to ensure the system performance in the airborne operating environment is satisfactory. The requirement for and the extent of a flight test required by a configuration change should be assessed based on the influence the change has on airborne performance, and the validity of ground testing in characterizing the airborne performance. Periodic flight test should be scheduled based on the rate of change in the environment at the procedure's location. For precision approach facilities a nominal interval of twelve months is suggested.

1.16 FLIGHT INSPECTION AT NIGHT

1.16.1 Information on this topic is contained in Chapter 1 of Doc 8071, Volume I. It is recommended that each State develop procedures according to the aircraft and flight inspection system used, as well as the characteristics of the terrain.

1.16.2 GNSS signals are susceptible to the effects of increased solar activity on the ionosphere. This may cause differences between night and day flight tests.

ATTACHMENT 1 TO CHAPTER 1

FLIGHT INSPECTION AIRCRAFT

1. GENERAL CHARACTERISTICS

1.1 Information on this topic is contained in Chapter 1 of Doc. 8071, Volume I. It includes general characteristics; aircraft instrumentation; selection of antennas; flight inspection receivers and radio communication equipment; data processing, display and recording; and regulatory aspects.

2. GNSS-UNIQUE CHARACTERISTICS

Recorded parameters

2.1 Recording of GNSS parameters during the flight test is not required for NPA. However, the parameters in Table 1, 2, and 3 can support analysis of GNSS signal anomalies or interference encountered.

Table II-1-1. GNSS parameters

<i>Parameter</i>	<i>Definition</i>	<i>Purpose</i>
Cross Track Distance	The across track distance computed by the GNSS Receiver or FMS with GNSS sensor.	Provides a continuous record of the Total System Error component perpendicular to the desired track segments.
Active Waypoint	The active waypoint identifier.	Gives a continuous indication of the active waypoint
Distance to Active Waypoint	Distance to the active waypoint in nautical miles	Provides a continuous record of the GNSS Receiver computed distance to the active waypoint.
Bearing to Active Waypoint	Bearing to the active waypoint	Provides a continuous record of the GNSS Receiver computed true bearing to the active waypoint.
No. of SVs Visible	The number of Space Vehicles visible to the GNSS sensor.	Continuous indication of the SVs in view.
No. of SVs Tracked	The number of Space Vehicles being tracked by the GNSS sensor.	Continuous indication of those SVs for which a range solution is being tracked.
Carrier to Noise Density Ratio	The carrier to noise density for each satellite visible to the GNSS sensor.	Continuous indication of received C/N ₀ from each SV. Useful for investigating interference problems.
HDOP	Horizontal Dilution of Precision.	Continuous indication of the geometric dilution of the GNSS position accuracy in the horizontal plane.
RAIM Alarm	Indicator of lost GNSS signal integrity as computed by the GNSS receiver/sensor RAIM algorithm.	Continuous indication of RAIM alarm status. Can be used to investigate loss of RAIM occurrences along with other inputs such as HDOP, HFOM, aircraft attitude (roll, pitch and heading) and SV carrier to noise.
Date and Time	GNSS UTC Date and Time	Provides an accurate time for each GNSS position solution to be compared to a reference system.
GNSS Position	Present position Latitude and Longitude.	Provides a continuous indication of the GNSS position

Table II-1-2. Flight test system parameters

<i>Parameter</i>	<i>Definition</i>	<i>Purpose</i>
XTKER	The across track error. Derived by calculating the position difference between the GNSS and the positioning system, and then extracting the vector component that is 90 degrees from the track heading.	Provides a continuous record of the NSE (Navigation Sensor Error) component perpendicular to the desired track.
ATKER	The along track error. Derived by calculating the position difference between the GNSS and the positioning system, and then extracting the vector that is in the direction of the track heading.	Provides a continuous record of the NSE (Navigation Sensor Error) component in the direction of the desired track.
WPDE	Waypoint displacement error is the vector sum of the XTKER + ATKER	Can be calculated for the point at which the position reference system indicates the aircraft is abeam the waypoint being checked. Includes known errors inherent in the measurement system used.
Positioning system position data	Precise position of the GNSS antenna relative to the position system reference frame.	Provides a continuous record of the GNSS antenna position.
Positioning system time	Position system time tag. Preferably in UTC or GNSS time.	Provides a continuous record position reference time for correlation with GNSS position data.
Positioning system status	Operational status of the positioning system.	Provides continuous indication of the operational status of the position reference system.

Table II-1-3. Interference parameters

<i>Parameter</i>	<i>Definition</i>	<i>Purpose</i>
RAIM warning flag	Receiver Autonomous Integrity Monitoring is able to detect excessive pseudorange errors	Cannot discriminate between interference, shading, multipath and other anomalies
Receiver interference flag	Some GNSS receivers are equipped with an interference detection capability.	Detects interference by monitoring of the amplitude distribution (e.g. signal is buried in the noise, therefore amplitude has Gaussian distribution, amplitude distribution is distorted by interference signal).
C/N or C/N ₀	Signal to Noise or Signal to Noise density ratio, indicates quality of signal	C/N or C/N ₀ will be degraded during reception of an interference signal. To detect degradation value of C/N, or C/N ₀ has to be compared with undisturbed value of satellite with same elevation angle. Attitude of aircraft has to be taken into account.
Spectrum analyzer measurements	Spectrum analyzer equipment can be used to monitor the input to the GNSS receiver for signal levels which exceed the receiver interference protection criteria as specified in GNSS SARPs	This measurement is dependent on achieving a measurement noise threshold in the area of -153.5 dBW for GPS non-precision approach, -150.5 dBW for GPS precision approach. Assessment of CW interference signals can be achieved by comparison with interference threshold mask. Assessment of broadband and pulsed interference signals requires high effort. It is desirable to calibrate the level into the spectrum analyzer relative to an isotropic antenna output.

ATTACHMENT 2 TO CHAPTER 1
DOCUMENTATION AND DATA RECORDING

1. GENERAL INFORMATION

1.1 Information on this topic is contained in Doc. 8071, Volume I, Chapter 1.

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ATTACHMENT 3 TO CHAPTER 1**INTERFERENCE ISSUES****1. GENERAL INFORMATION**

Additional information on interference issues is contained in Doc. 8071, Volume I, Chapter 1, Appendix 3.

2. INTERFERENCE**Potential for interference**

2.1 The potential for interference exists to various extent in all radio navigation bands. As with any navigation system, the users of GNSS signals must be protected from harmful interference resulting in the degradation of achieved navigation performance.

2.2 Current satellite navigation systems provide weak received signal power – meaning that an interference signal can cause loss of service at a lower receiver power level than with current terrestrial navigation systems. Interference exist wherever the GNSS signal is authorized for use. GNSS is however, more resistant to misleading navigation errors from interference signals than current terrestrial radio navigation systems.

Spectrum allocations

2.3 Both current core satellite constellations, GPS and GLONASS, operate using the radio frequency (RF) spectrum allocated by the International Telecommunications Union (ITU). States authorizing GPS- or GLONASS-based operations have an obligation to ensure that their national frequency allocations and assignments in the 1559-1610 MHz band do not cause interference to GPS or GLONASS aviation users. Similarly, services operating in the adjacent bands should not generate harmful interference to GPS or GLONASS.

2.4 GPS and GLONASS operate using spectrum allocated to the aeronautical radio navigation service (ARNS) and radio navigation satellite services (RNSS). GPS, GLONASS and SBAS operate in segments of the 1559-1610 MHz frequency band allocated to ARNS and RNSS.

2.5 GBAS operates in the 108-117.975 MHz band allocated to ARNS.

3. SOURCES OF INTERFERENCE**In-band sources**

3.1 A potential source of in-band harmful interference is that of fixed-service operation in certain States. There are primary or secondary allocations to the fixed-service for point-to-point microwave links in certain States in the frequency band used by GPS and GLONASS.

3.2 It is expected that States authorizing GNSS operations endeavor to ensure that existing and future frequency assignments in the 1559-1610 MHz band with the potential to interfere with the GNSS operations be moved to other frequency bands.

Out-of-band sources

3.3 Potential sources of interference from services operating in bands outside the 1559-1610 MHz band include harmonics and spurious emissions of aeronautical VHF transmitters, VHF and UHF television (TV) broadcast stations, and other high-power sources. Out-of-band noise, discrete spurious products and intermodulation products (IMP) from radio services operating near the 1559-1610 MHz band can also cause interference problems.

3.4 Studies have shown that commercial VHF transmissions do not pose an operationally significant threat to GNSS users. However, further consideration should be given to this threat for specific VHF transmit antennas located in the vicinity of a runway and approach areas.

3.5 Television stations do pose a threat to GNSS. Given current limitations on out-of-band emissions from the TV transmitters, it is feasible for a transmitter operating within specifications to radiate significant power into the GPS L1 band. Future TV systems such as High Definition TV may be capable of causing significant interference to GNSS receivers. Therefore, there is a need for mitigation strategies to prevent operational impacts to GNSS aviation users operating in the airport vicinity. As the spurious emission characteristics of TV transmitters change over time (due to maintenance, weather conditions, etc.) there will be a need for an on-going interference mitigation strategy on the behalf of the affected air traffic service provider.

Onboard sources

3.6 The potential for harmful interference to GPS and GLONASS on an aircraft depends on the individual aircraft, its size, and what transmitting equipment is installed. The GNSS antenna location should take into account the possibility of onboard interference – mainly emanating from satellite communication equipment.

3.7 On large aircraft sufficient isolation between a transmitting antenna and a GNSS receiving antenna can usually be obtained to mitigate an interference problem. Transmitters of particular interest are the satellite communications equipment and VHF transmitters. The possible generation of intermodulation products on the aircraft from one transmitter with multiple carriers or multiple transmitters is controlled by a combination of transmitter filtering and frequency management. Some onboard interference could be due to harmonics generated by weathered joints and connections. It is recommended that air operators and State regulatory authorities take action to control such occurrences.

3.8 Avionics must be installed in accordance with industry standards to ensure that the equipment operates properly. These standards require testing for interference with and by other onboard systems.

3.9 The combination of appropriately shielded GPS and GLONASS antenna cabling, separation of antennas and cables, and transmitter filters can solve most interference problems onboard small aircraft. Transmit equipment should be filtered within its own box or as close to the transmit-antenna port as possible. Additionally, some personal electronic devices are capable of generating sufficient in-band energy to interfere with avionics when used onboard an aircraft.

Malicious interference

3.10 Intentional malicious interference (jamming) to GNSS is also a possibility as it is to all radio navigation systems. Such unauthorized interference is illegal and should be dealt with by the appropriate State authorities.

3.11 Spoofing of GNSS receivers can be made extremely difficult with proper design of the receiver autonomous integrity monitoring (RAIM) and fault detection and exclusion (FDE) algorithms resident in aviation receiver equipment.

4. REGULATORY REQUIREMENTS

4.1 Protection of the aeronautical radio navigation safety services spectrum is of paramount importance. International regulations state that the aeronautical radio navigation service is afforded special protection. The ITU Radio Regulation (RR) 953 states:

"Members recognize that the safety aspects of radio navigation 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."

Each State wishing to implement GNSS in support of air traffic services should ensure that regulations are in place to protect the aeronautical radio navigation spectrum allocated satellite navigation.

Interference detection, flight inspection and ground monitoring

4.2 Reliance on GNSS will require a State to reexamine their respective capabilities to detect, localize and identify interference sources in order to minimize potential service disruptions in their flight information regions. This examination may result in planning efforts to investigate a need for airborne and ground-based systems for detecting and localizing potential sources of RF interference (RFI) to the GNSS signals.

4.3 In order to quickly identify and mitigate GNSS interference, a suite of systems may be required. Current technology provides RFI direction finding (DF) and localization capabilities available in four main platforms of interest – aircraft, land fixed (e.g., airport), land mobile (surface vehicle), and handheld. Cooperative efforts between the responsible regulatory organizations within a State, utilizing such a suite of systems, will provide the capability to locate and initiate measures to terminate sources of interference.

4.4 The extent of development a particular State may desire to implement should be predicated on the extent of operational services provided by GNSS and required availability for those services.

4.5 Interference is of primary concern for the approach and landing operations. States and ATS providers have an obligation to validate the interference environment

as part of the flight inspection of the approach operation. This can be carried out by a spectrum analysis of the frequency ranges of GPS and GLONASS (and their respective augmentation signals). In this way it is possible to identify any unintentional interference that has the potential to disrupt approach operations.

4.6 GNSS receivers for approach operations, developed in accordance with guidance material in the SARPs, are required to achieve a minimum level of performance in the presence of both continuous wave (CW) and pulsed interference. To assess the potential impact of received signals, a comparison of the received spectrum with the interference masks specified in the SARPs is recommended. If no incursion of the CW interference is detected, the environment can be regarded as satisfactory. Since the interference masks are only valid for the most harmful CW interference, further (post-processing) analysis of the spectrum is necessary if broadband or pulsed signals exceed the interference mask.

4.7 To achieve the required measurement sensitivity, a suitable preamplifier and a resolution bandwidth of 10 kHz or less are required. It is desirable to analyze the frequency ranges of GPS (1575 ± 20 MHz) and GLONASS (1598–20 MHz to $1604.25+20$ MHz). It is recommended to use a digital signal processing (DSP) receiver rather than a spectrum analyzer since only DSP-receivers allow a satisfactory sweep rate.

4.8 If the primary aim is just to detect interference, a GPS or GPS/GLONASS antenna with an appropriate pre-amplifier can be used. If a location of the interference source is to be determined, a direction finding antenna or a multi-channel DSP receiver with direction finding capability should be used.

4.9 The extent of the required interference monitoring equipment depends on the extent of operational services provided by GNSS and the required availability for those services. At airports with very high traffic that rely on GNSS as the navigation means for approach, it may be desirable to deploy a permanent interference monitoring station. In this way a timely notification to ATC of the threat of interference can be performed.

4.10 Even with a flight inspection there is no full guarantee that all interference sources have been identified. For example, some sources may be intermittent transmitters or may come from mobile transmitters. Therefore it is recommended aircraft are equipped with interference sensors (GNSS receivers

with interference detection capability producing automatic reports). In this way the ATC operator can collect and analyze reports to obtain information on the spatial distribution of interference events.

4.11 In addition to the analysis of the spectrum, a GNSS receiver should be used to determine the impact of interference to the GNSS data.

5. MITIGATION TECHNIQUES

Regulatory techniques

5.1 There is always the possibility of interference and aircraft CNS systems should be designed with this potential in mind. Aircraft certification and installation procedures should require demonstration of protection against onboard harmful interference.

5.2 The most effective place to deal with interference is at its source. Assuming that regulatory authorities have implemented suitable performance standards, filters can be mandated to limit out-of-band emissions.

5.3 The combined use of GPS and GLONASS in the same receiver provides a more robust design against certain interference than GPS alone and GLONASS alone due to the use of multiple frequencies. However, careful design must be employed as a common wide-band RF front-end to a GPS/GLONASS receiver has the potential to increase the level of interference rather than decrease it.

5.4 Control of the harmonic content will be necessary where TV transmitters cause interference. One State has TV transmitters with harmonics that are over 100 dB less than the carrier. This is 40 dB greater than that required by regulation. If the regulation were changed to be in conformance with what can be achieved and is typical in some States, then interference protection from TV transmissions could be assured. Depending upon the adequacy of existing standards and practice, the cost to the aviation community of additional filters for TV broadcast stations to protect GNSS operations may be reasonable.

5.5 It is important to evaluate airspace where aircraft are authorized to fly to identify potential sources of interference. If interference does exist, then consideration should be given to filtering the source transmitter, avoidance of the source where operationally feasible, or moving the transmitter to another frequency band.

INS coupling

5.6 Protection can be obtained from the effects of interference through the coupling of GNSS receivers with Inertial Navigation Systems (INS). The characteristics of both systems are complementary. INS is immune to external interference and offers excellent short-term position stability but suffers from a bias error that increases with the time from its last position update. GNSS on the other hand has excellent long-term position stability but can suffer from short-term signal outages including those caused by transient interference.

5.7 However, INS coupling should be considered as an extra margin for unforeseen interference events. It is not recommended that the added benefit of inertial guidance be credited as an interference mitigation technique.

Adaptive antennas and adaptive notch filters

5.8 Both adaptive antenna and notch filter technologies have been applied to GNSS to help overcome the problems of interference. These technologies were originally developed to protect military users from hostile jamming of the GNSS signals and are now found in civil applications. Both techniques require additional airborne equipment, but once installed can provide significant protection from unintentional interference.

Airframe masking and antenna locations

5.9 Airframe shielding of the top-mounted GNSS antenna from ground-based transmitters can offer additional mitigation against interference. The radiation pattern of the antenna and the antenna's position on the aircraft are important in rejecting ground-based interference.

FM broadcast compatibility issues for GBAS

5.10 Receivers for the Instrument Landing System (ILS) have been shown to be susceptible to interference from two- and three-signal 3rd order and 5th order intermodulation products from commercial radio broadcast stations operating in the band adjacent to the bottom of the 108-117.975 MHz ARNS band where ILS localizers operate. VHF FM broadcasters have

been allowed frequency assignments below 108 MHz assuming interference immunity performance of ILS receivers specified in Annex 10, Volume I, 3.1.4.

5.11 States currently require coordination between FM broadcasters and ILS localizer installations to protect users from the possibility of harmful unintentional interference arising from intermodulation products. The same form of protection is required for GBAS which receivers employ the same interference immunity standards (Annex 10, Volume I, Appendix B, 3.6.8.2.2.8.3).

6. SUMMARY

6.1 Interference from unintentional or intentional sources can present a risk to the safe use of GNSS, noticeably for precision approach and landing operations. This is due to the fact that GNSS signals are of a low power when received by a user receiver. However, there are many steps that can be taken to overcome the influence of interference – technically, institutionally and operationally.

6.2 From a technical perspective, judicious siting of the aircraft GNSS antenna well away from satellite communications antennas and other high effective radiated power systems will provide mitigation from onboard interference sources. At the same time, consideration should be given to siting the antenna to optimize airframe shielding from ground-based interference. Adaptive antennas, notch filters and INS coupling all provide increasing levels of protection from interference effectively negating the threat altogether.

6.3 Flight inspection of GNSS approaches for interference combined with the use of ground-based monitoring and the provision of timely status information to ATC will act to protect the users of GNSS. At an institutional level, both ATS providers and States must take all necessary steps to protect users of radio navigation satellite services by ensuring proper policing of the GNSS spectrum and strict application of the ITU Radio Regulations.

6.4 The key issue for States to recognize is that of all the techniques available to mitigate interference, only those appropriate to the airfield and operations being undertaken need to be put in place. There is no need to unnecessarily burden the users or the ATS providers where no risk exists.

ATTACHMENT 4 TO CHAPTER 1**GNSS SYSTEM DESCRIPTIONS****1. CORE SATELLITE CONSTELLATIONS**

1.1 Core satellite constellations, GPS and GLONASS, are currently defined in Annex 10, Volume I, Chapter 3, 3.7.

2. GLOBAL POSITIONING SYSTEM (GPS)

2.1 GPS is a satellite-based radio navigation system which utilizes range measurements from the GPS satellites to determine precise position and time anywhere in the world. The system is managed for the government of the United States by the United States Air Force, the system operator.

2.2 The Standard Positioning Service (SPS) provides a coarse acquisition code (C/A-code) centred at the L1 frequency (1575.42 MHz).

2.3 Selective Availability (SA) is a method by which significant clock and ephemeris errors can be created in the satellite navigation data to deny the use of precise GPS position data. GPS SA was discontinued as of 1 May 2000.

2.4 The GPS has three major segments: space, control and user.

2.5 The GPS space segment is composed of 24 satellites in six orbital planes. The satellites operate in near-circular 20 200 km (10 900 NM) orbits at an inclination angle of 55 degrees to the equator, and each satellite completes an orbit in approximately 12 hours. The satellite orbits are arranged so that a minimum of four satellites, with a position dilution of precision (PDOP) of 6 and a 5-degree mask angle, are in view to users with a global average availability of 99.75 percent with 24 operational satellites. The satellites broadcast a pseudo-random code-based timing signal and a data message that the airborne equipment processes to obtain satellite position and status. Every satellite's exact measured orbital parameters (ephemeris data) are broadcast as part of a data message sent in the GPS signal.

2.6 The GPS control segment has five monitor stations and three ground antennas with up-link capabilities. The monitor stations use a GPS receiver to passively track all satellites in view and accumulate ranging data from the satellite signals. The information from the

monitor stations is processed at the master control station to determine satellite clock and orbit states and to update the navigation message of each satellite. This information is transmitted to the satellites via the ground antennas, which are also used for transmitting and receiving health and control information.

2.7 The GPS user segment consists of an antenna and receiver-processor to receive and compute navigation solutions to provide positioning and precise timing to the user. By knowing the precise location of each satellite and precisely matching timing with the atomic clocks on the satellites, the receiver can solve four simultaneous equations for time offset and the three components of position.

2.8 Measurements from a minimum of four satellites are required to establish three-dimensional position and time. Three satellite measurements are required to determine a two-dimensional position and time if altitude is known. Accuracy is dependent on the precision of the measurements from the satellites and the geometry of the satellites used.

3. GLOBAL NAVIGATION SATELLITE SYSTEM (GLONASS)

3.1 The GLONASS provides signals from space for accurate determination of position, velocity, and time for properly equipped users. GLONASS will provide high accuracy and availability to users. Navigation coverage will be continuous, worldwide and all weather. Three-dimensional position and velocity determinations are based upon the measurement of transit time and Doppler shift of RF signals transmitted by GLONASS satellites. The system is managed for the government of the Russian Federation by the RF Ministry of Defence.

3.2 The nominal GLONASS space segment consists of 24 operational satellites and several spares. GLONASS satellites orbit at an altitude of 19 100 km (10 325 NM).

3.3 A navigation message transmitted from each satellite consists of satellite coordinates, velocity vector components, corrections to GLONASS system time, and satellite health information. To obtain a system fix, a user's receiver tracks at least four satellite signals, either simultaneously or sequentially, and solves four

simultaneous equations for the three components of position and time.

3.4 The Channel of Standard Accuracy (CSA) has a frequency division multiple access (FDMA). Each channel is centred on the frequency $L1 = 1602 \text{ MHz} + n * 0.5625 \text{ MHz}$, where "n" is the frequency channel number ($n = 0, 1, 2, \dots$). Each satellite transmits signals on its own frequency. However, those satellites placed in antipodal slots of orbit planes and not appearing at the same time in a user's view have the same frequency. After 1998, the GLONASS channels began to shift down in frequency until the spectrum range is from 1598 to 1604.25 MHz.

3.5 GLONASS navigation data message provides information regarding the status of the individual transmitting satellite along with information on the remainder of the satellite constellation. From a user's perspective, the primary elements of information in a GLONASS satellite transmission are the clock correction parameters and the satellite position (ephemeris). GLONASS clock corrections provide data detailing the difference between the individual satellite's time and GLONASS system time, which is related to UTC.

4. AUGMENTATION SYSTEMS

4.1 Three augmentation systems – aircraft-based augmentation system (ABAS), satellited-based augmentation system (SBAS) and ground-based augmentation system (GBAS) – are currently defined in GNSS SARPs in Annex 10, Volume I, Chapter 3, 3.7.

4.2 Guidance material on augmentation systems is provided in Attachment D to Annex 10, Volume I.

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Chapter 2

AIRCRAFT-BASED AUGMENTATION SYSTEMS

NON-PRECISION APPROACH (NPA) PROCEDURES

2.1 INTRODUCTION

General

2.1.1 This Chapter details the ground and flight test procedures and tolerances to be applied to ABAS non-precision approach (NPA) procedures. For the purposes of this chapter, “ABAS procedures” means “GNSS + RAIM” and “GNSS + RAIM + barometric altimetry”, excluding computed vertical guidance.

System description

2.1.2 Aircraft-based augmentation system (ABAS) augments and/or integrates the information obtained from GNSS elements with information available onboard the aircraft. Chapter 1 provides a general description of GPS and GLONASS, which are used as the foundation for ABAS procedures. Basic forms of ABAS are described briefly below.

RAIM

2.1.3 Receiver Autonomous Integrity Monitoring (RAIM) uses GNSS information exclusively to provide integrity monitoring for the position solution using redundant information (e.g. multiple range measurements). The monitoring scheme generally employs two options: fault detection (FD), or fault detection and exclusion (FDE). The goal of FD is to detect the presence of a positioning failure for a given phase of flight. FDE determines and excludes the source of the failure (without necessarily identifying the individual source causing the problem), thereby allowing GNSS navigation to continue without interruption.

Barometric aiding

2.1.4 The integrity monitoring and availability of the position solution can be aided by using information from the barometric altimeter onboard the aircraft, thus reducing by one the required number of satellites in view.

2.1.5 Reserved.

2.1.6 Reserved.

Testing requirements

2.1.7 A summary of testing requirements is given in Table II-2-1.

2.2 GROUND TESTING/INSPECTION

General

2.2.1 There is no requirement for local, on-site evaluation of the GNSS signals-in-space. Guidance on the accuracy of the survey data used for the procedure design, and for ground interference checking, is given in Chapter 1.

2.2.2 Reserved.

2.2.3 Reserved.

2.2.4 Reserved.

2.2.5 Reserved.

2.3 FLIGHT TESTING/INSPECTION

General

2.3.1 Flight testing/inspection of the GNSS signals-in-space is not required. Flight test is concerned with validation of instrument flight procedures and adequate GNSS signal reception for the specific approach.

Flight test performance parameters

2.3.2 A summary of flight test requirements is given in Table II-2-3.

Flight test/inspection procedures

Pre-departure checks

2.3.3 GNSS instrument flight procedures consist of sequenced waypoints. The entire sequence of waypoints must be entered into the GNSS receiver for commissioning flight tests, and selected from the GNSS receiver database for routine tests.

Waypoint and procedure design correlation

2.3.4 The procedures should be evaluated before flight testing by entering the waypoints in the avionics, and verifying the avionics display of range, and bearing between waypoints is correlated with the procedure design information. Care should be used to ensure that all headings are in the same unit of measurement (e.g., true or magnetic).

RAIM prediction

2.3.5 Before flight testing begins, RAIM predictions should confirm that the GNSS signals will support the flight testing without RAIM alerts. Any value of Dilution of Precision (DOP) that also meets RAIM requirements is satisfactory for the flight testing.

In-flight activities

Maneuvering

2.3.6 The entire procedure should be flown, including Initial, Intermediate, Final Approach, and Missed Approach segments. Alternate or additional segments should be checked on commissioning to the point where the routing intersects a portion of the procedure already checked. The intent is that each segment of the procedure should be flown at least once; common segments do not need to be repeated.

Verification of missed approach waypoint

2.3.7 The position of the MAWP must be confirmed with respect to the physical environment. This verification may be achieved either visually or electronically, and descent below the published minima may be necessary. A truth system may be used when visual verification is not practical, such as for over-water or some non-threshold MAWPs. Consideration must be given to the types of aircraft that will be using the procedure and the runway environment.

Interference

2.3.8 For NPA approaches, the presence of a RAIM alert and/or the loss of guidance have proven to be good indicators of probable GNSS interference, affecting availability rather than accuracy or integrity. Although relying on these indicators does not actually confirm that the spectrum environment meets the resistance-to-interference standards in Annex 10, Volume I, Chapter 3, 3.7.4, it is considered sufficient for the procedures covered by this Chapter. Furthermore, the presence of interfering signals for NPA approaches may not require a procedural restriction unless GNSS receiver performance is affected. However, if interference is suspected, further investigation should be conducted. The suspected area should be probed to define its geographical extent, GNSS parameters such as signal/noise ratios and DOP should be documented, the approach procedure should be removed from operational status, and appropriate authorities should be notified.

Evaluation

2.3.9 Evaluation should confirm the continuous presence of guidance information, the absence of RAIM alerts and the location of the GNSS-indicated MAWP (see Table II-2-3). Visual confirmation should ensure that the final approach course and distance to the MAWP coincide with the intended final approach course and satisfactorily deliver the aircraft to the desired point established for landing. It should also be confirmed that the approach is flyable by taking into account the types of aircraft that will be using the procedure and such factors as the descent gradient, segment length, alignment in final, pilot workload and runway environment.

Charts and reports

Maps and charts for flight testing

2.3.10 The pilot or crew member responsible for the flight testing should have appropriate topographical maps and procedure charts of the approach area to the runway to be tested, showing the runway, and identifying prominent landmarks and waypoint locations of the procedure. The available set of documentation for flight inspection should include all relevant data such as procedure design, segment lengths, bearings, and descent and climb angles. For more details, refer to Volume I of Doc. 8071.

Report forms

2.3.11 The flight testing of a GNSS instrument flight procedure should be documented through the use of an appropriate report as a record of the adequacy of the procedure and its environment. The report should contain, at minimum, information on the aircraft used, the testing date, the procedure flown, a summary of results including MAWP location, the operational status of the procedure, and the signature of the responsible person. In addition, when interference is suspected, a description of the affected geographical area, observation times, and the GNSS signal parameters observed should be included. An example report with associated checklists and worksheets is shown in Figure II-2-1.

Test equipment

2.3.12 The aircraft used for these procedural and interference tests may be of any type, if it is equipped with an appropriate receiver and external aerial/antenna installed and approved for that aircraft type.

ABAS receiver

2.3.13 The aircraft receiver should meet the appropriate type approval requirements for GPS and/or GLONASS-based procedures as applicable.

GLONASS

2.3.14 Reserved.

Table II-2-1 Summary of testing requirements – ABAS procedures

<i>Parameter</i>	<i>Annex 10, Volume I reference</i>	<i>Testing</i>
Procedure Design	(none)	F
Interference	Chapter 3, 3.7.4	F

*Note: F – Flight test/inspection
G – Ground test*

Table II-2-2. Reserved.

Table II-2-3 Summary of minimum flight test requirements – ABAS procedures

<i>Parameter</i>	<i>Annex 10, Volume I reference</i>	<i>Doc 8071 reference</i>	<i>Measurand</i>	<i>Tolerance/Limit</i>	<i>Uncertainty</i>	<i>Periodicity</i>
Procedure design validation (all segments)	(none)	2.3.4				C
Bearing to next waypoint			Degrees	$\pm 0.1^\circ$	$\pm 0.05^\circ$	
Distance to next waypoint			metres (nautical miles)	± 185 m (± 0.1 NM)	± 106 m	
Waypoint data			coordinates	entered to hundredths of a minute	± 18 m	
MAWP GNSS-indicated location	(none)	2.3.7	Displacement	visual verification	Subjective	C, Sp
Interference	Chapter 3, 3.7.4	2.3.8	RAIM alerts	No alerts	None	C, Sp
			Guidance	Continuous		

			indications	guidance		
Guidance indications	(none)	2.3.9	Nav indicator	Continuous	None	C, Sp
Flyability	(none)	2.3.9		Flyable	Subjective	C, Sp

Note: C - Commissioning (and when published design changes to the procedure occur)

Sp - Special, e.g. when interference is suspected or periodic interference check is desired

Figure II-2-1 Example worksheets, checklists, and report forms – ABAS Procedures

GPS IAP WAYPOINT VERIFICATION WORKSHEET (RUNWAY)

Date: _____

Aerodrome: _____

Procedure: _____

Checked by: _____

Runway Survey:

WPT	POSITION	COMPUTED BRG, T	MAG VAR	COMPUTED BRG, M	PUBLISHED BRG, M	COMPUTED DISTANCE	RW LENGTH
Threshold	N W						
Departure End	N W						

Assessment: _____

In Northern Domestic Airspace, set MAG VAR to 0 and perform all computations using true bearings.

GPS IAP WAYPOINT VERIFICATION WORKSHEET

Date: _____

Aerodrome: _____

Procedure: _____

Checked by: _____

LEG	COMPUTED BRG, T	MAG VAR	COMPUTED BRG, M	DESIGN BRG, M	COMPUTED DISTANCE	DESIGN DISTANCE	PASS/FAIL
IAWPL-IWP							
IAWPR-IWP							
IAWPC-IWP							
IWP-SDWP (A/R)							
IWP-FAWP							
FAWP-SDWP (A/R)							
FAWP-MAWP							
MAWP-MATWP (A/R)							
MATWP-MAHWP (A/R)							
MAWP-MAHWP (A/R)							

In Northern Domestic Airspace, set MAG VAR to 0 and perform all computations using true bearings.

GPS IAP FLIGHT INSPECTION CHECKLIST – PLANNING & PREFLIGHT

Aerodrome: _____

Procedure: _____

Date: _____

Inspector: _____

Type of Inspection: _____

Documentation & Tools	Supporting Information
Checklists ☐	Anticipated date/time of inspection
IAP form ☐	Wx
Inspection forms ☐	Constellation Predictions:
Approach Plate ☐	RAIM (HIL)
Topographic Maps ☐	Number of Sats
Data Collection System/DTU ☐	HDOP
Blank Disks ☐	ATC Co-ordination ☐
Flight Plan	Contact Airport Authority ☐
Program FMS/GPS ☐	Survey worksheet complete ☐
Wpt Entry Verification ☐	Waypoint worksheet complete ☐
Leg Lengths/Tracks..... ☐	
Duplicate Waypoints..... ☐	

WAYPOINT VERIFICATION (AVIONICS)

LEG	WPTS	DIST	DESIGN DIST	TK	DESIGN TK	PASS
Initial L						
Initial C						
Initial R						
Intermediate						
Final						
Missed						

GPS IAP FLIGHT INSPECTION CHECKLIST – INFLIGHT

Aerodrome: _____

Procedure: _____

Date: _____

Inspector: _____

Altimeter Setting Source _____ Wpt Entry Verification ☐ Leg Lengths/Tracks..... ☐	Duplicate Waypoints..... ☐ Deselect Non-GPS Sensors ☐ Start Data Recording ☐
Obstacle Verification: Initial L ☐ Initial R ☐ Initial C ☐ Intermediate ☐ Final ☐ Missed ☐ Circling ☐ 25 NM MSA ☐ Departure ☐	Confirm Waypoint Positions: IAWL ☐ IAWPR ☐ IAWPC ☐ IWP ☐ SDWP..... ☐ FAWP..... ☐ SDWP..... ☐ MAWP..... ☐ MATWP ☐ MAHWP..... ☐
Confirm MAWP Position: N _____ XTE _____ W _____ ATE _____ Num Sats _____ HDOP _____	
Comments:	

GPS IAP FLIGHT INSPECTION CHECKLIST – OPERATIONAL ACCEPTABILITY

Aerodrome: _____ Procedure: _____

Date: _____ Inspector: _____

A/C Type: _____ Pilot Flying: _____

Intended User A/C - (GA, Helo, Commuter, B/Jet, Heavy, Military)
 (Circle significant types)

Intended Use:		Flyability:	
Airspace	☐	Suitable for Critical A/C	☐
Noise	☐	Descent Gradient	☐
Environmental	☐	Segment Length	☐
Communications	☐	Alignment on Final	☐
Surveillance	☐	Gradient/Alignment Combo	☐
Approach Plate	☐		
Aerodrome Facilities.....	☐		
		Workload Rating _____	
		<i>(1-7 acceptable, 8-10 excessive)</i>	

Comments:

OVERALL ASSESSMENT - Pass

Fail

(Inspector Signature)

**GPS IAP FLIGHT INSPECTION WORKSHEET
INTERFERENCE & SIGNAL AVAILABILITY**

Aerodrome: _____ Procedure: _____

Date: _____ Inspector: _____

LEG	HDOP	NUM SATS	RAIM STATUS
Initial L			
Initial R			
Initial C			
Intermediate			
Final			
Missed			
Departure			

Comments:

GPS IAP FLIGHT INSPECTION – SUMMARY

Aerodrome: _____

Procedure: _____

Date: _____

Inspector: _____

Assessments:

Survey Verification	☐
Waypoint Verification	☐
Topo Map Wpt Verification	☐
Signal Coverage	☐
Interference	☐
Obstacle Verification	☐
MAWP Verification	☐
Operational Acceptability	☐

Overall Assessment:

PASS

FAIL

NOTAM issued: ☐

Inspector Signature: _____

— END —