

APPENDIX C**DRAFT AMENDMENTS TO THE *GLOBAL AIR NAVIGATION PLAN*
FOR CNS/ATM SYSTEMS (DOC 9750)****NOTES ON THE PRESENTATION OF THE PROPOSED AMENDMENT**

1. The text of the amendment is arranged to show deleted text with a line through it and new text highlighted with grey shading, as shown below:

~~Text to be deleted is shown with a line through it.~~

text to be deleted

New text to be inserted is highlighted with grey shading.

new text to be inserted

~~Text to be deleted is shown with a line through it~~ followed
by the replacement text which is highlighted with grey
shading.

new text to replace existing text

GLOBAL AIR NAVIGATION PLAN FOR CNS/ATM SYSTEMS

...

Editorial Note.— The table of contents is reproduced in part and expanded to highlight, in bold, the parts of the document that are affected by this amendment.

TABLE OF CONTENTS

Page

...

**PART I. OPERATIONAL CONCEPT AND
GENERAL PLANNING PRINCIPLES**

Chapter 1. Introduction to CNS/ATM

...

A brief look at CNS/ATM	I-1-3
Communications	
Navigation	
Surveillance	
Air traffic management	

...

Chapter 2. ICAO'S planning structure for CNS/ATM

...

APPENDIX A. Statement of ICAO policy on CNS/ATM systems

implementation and operation I-2-7

1. Universal accessibility
2. Sovereignty, authority and responsibility of Contracting States
3. Responsibility and role of ICAO
4. Technical cooperation
5. Institutional arrangements and implementation
- 6. Global navigation satellite system**

...

Chapter 4. Air traffic management

...

Chapter 6. Navigation systems

Objectives I-6-1**Required navigation performance (RNP)** I-6-1**Global navigation satellite system (GNSS)** I-6-1**GNSS augmentations** I-6-2**Avionics** I-6-3**WGS-84 coordinate system and aeronautical databases** I-6-3**Evolutionary introduction** I-6-3**Systems to support approach, landing and departure operations** I-6-3**General transition issues** I-6-4

...

Chapter 12. Organizational and international cooperative aspects

Introduction I-12-1

Organizational forms at the national level I-12-1

Specific operational and technical organizational aspects I-12-2

General

Aeronautical Mobile Satellite Services (AMSS) — implementation and option selection

Global Navigation Satellite System (GNSS)

Air traffic management (ATM)

...

PART I

Operational Concept and General Planning Principles

Chapter 1

INTRODUCTION TO CNS/ATM

...

A BRIEF LOOK AT CNS/ATM

...

Navigation

1.20 Improvements in navigation include the progressive introduction of area navigation (RNAV), ~~capabilities along with the~~ supported by an appropriate combination of global navigation satellite system (GNSS), self-contained navigation systems (IRU/IRS) and conventional ground-based navigation aids. The ultimate goal is a transition to GNSS that would eliminate the requirement for ground-based aids, although the vulnerability of GNSS to interference may require the retention of some ground aids in specific areas. ~~These systems provide for worldwide navigational coverage and are being used for worldwide en-route navigation and for non-precision approaches. With appropriate augmentation systems and related procedures, it is expected that these systems will also support most precision approaches.~~

1.21 GNSS provides for global navigational coverage and is being used for oceanic, en-route and terminal navigation and for non-precision approaches. With appropriate augmentation systems and related procedures, GNSS supports approaches with vertical guidance and precision approaches. ~~GNSS, Core satellite constellation(s) with proper augmentation as specified in Annex 10, will~~ provides a high-integrity, high-accuracy and all-weather ~~worldwide~~ global navigation service. The ~~successful~~ full implementation of GNSS ~~would~~ will enable aircraft to navigate in all types of airspace, in any part of the world, using on-board avionics to receive and interpret satellite signals.

1.22 The introduction of GNSS offers ~~ing~~ the possibility for many States to dismantle some or all of their existing ground-based navigation infrastructure. However, the removal of conventional radio navigation aids should be considered with caution and after a safety assessment has demonstrated that an acceptable level of safety can be met and after consultation with users through the regional air navigation planning process.

1.23 The major benefits from the introduction of these navigation elements are summarized in Figure I-1-2.

Editorial Note.— Renumber subsequent paragraphs accordingly.

...

Amend Navigation section of Figure I-1-2 as follows:

Navigation	
!	High-integrity, high-reliability, all-weather global navigation services worldwide
!	Improved four-dimensional navigation position determination accuracy
!	Potential Cost savings from the reduction or non-implementation of ground-based navigation aids
!	Better More efficient airspace and airport and runway utilization
!	Provision of non-precision approach/precision approach NPA/PA improved approach capabilities at presently non-equipped airports
!	Potential to Reduced pilot workload
!	Ability to reduce the environmental impact through flexible routing

...

Chapter 2 ICAO'S PLANNING STRUCTURE FOR CNS/ATM

...

APPENDIX A TO CHAPTER 2

STATEMENT OF ICAO POLICY ON CNS/ATM SYSTEMS IMPLEMENTATION AND OPERATIONS

Approved by Council (C 141/13) on 9 March 1994

...

6. GLOBAL NAVIGATION SATELLITE SYSTEM

The global navigation satellite system (GNSS) ~~should~~ **is being** implemented as an evolutionary progression from existing global navigation satellite systems, including the United States' global positioning system (GPS), and the Russian Federation's global orbiting navigation satellite system (GLONASS), ~~towards an integrated GNSS over which Contracting States exercise a sufficient level of control on aspects related to its use by.~~ **States may obtain better control over the use of GNSS through the deployment of independent, interoperable systems or the implementation of augmentation systems, e.g. satellite-based augmentation systems or ground-based augmentation systems.**

The future GNSS will consist of multiple constellations and multiple frequency signals from the core constellations GPS, GLONASS and GALILEO which **is being** developed by the European Union member States. GPS will be enhanced by the addition of a second civil signal on L2 and, more importantly for aviation, a third civil signal on L5 which is in a protected aeronautical radio-navigation service (ARNS) frequency band. GLONASS is also evolving to add multiple frequencies available to civil users with the advent of the GLONASS-M and GLONASS-K satellites with second civil signal on L3 in the ARNS band. The GALILEO system will offer another constellation of navigation satellites with multiple frequency signals available to civil aviation. ICAO ~~shall continue~~ **s** to explore, in consultation with Contracting States, airspace users and service providers, the feasibility of achieving a civil internationally controlled **the use of multiple, interoperable GNSS elements.**

...

Chapter 4 AIR TRAFFIC MANAGEMENT

...

Note.— Chapter 4 is under review on the basis of material developed by the Air Traffic Management Operational Concept Panel (ATMCP). Proposed amendments to this chapter will be presented separately. Tables I-4 will be deleted in revised Chapter 4.

...

Chapter 6 NAVIGATION SYSTEMS

REFERENCES

Annex 10 *Aeronautical Telecommunications Guidelines for the Introduction and Operational Use of the Global Navigation Satellite System (GNSS) Manual* (Circular 267) (Doc)

Manual on Required Navigation Performance (RNP) (Doc 9613)

Annex 11 *Air Traffic Services Procedures for Air Navigation Services — Aircraft Operations* (Doc 8168, PANS-OPS)

OBJECTIVES

6.1 The navigation element of CNS/ATM systems is ~~meant~~ **intended** to provide **an** accurate, reliable and seamless ~~position determination~~ **global navigation (positioning)** capability, ~~worldwide, through introduction of satellite-based aeronautical navigation.~~ **Positioning is established using an appropriate mix of capabilities provided by satellite-based, self-contained navigation systems and/or ground-based navigation facilities.**

REQUIRED NAVIGATION PERFORMANCE (RNP) **AND** **AREA NAVIGATION (RNAV)**

6.2 Modern aircraft are increasingly equipped with RNAV systems, the use of which facilitates a flexible route system. Also, by using the concept of RNP, the need for selection between competing systems can be avoided. However, international standardization of navigation techniques, which are in wide use internationally, is still required. The application of RNAV in various parts of the world has already been shown to provide a number of advantages over conventional station-referenced navigation and benefits such as more direct routing.

6.3 The RNP concept applies to navigation performance within an airspace and therefore affects both the airspace and the aircraft. RNP is intended to characterize an airspace through a statement of the navigation performance (RNP type) to be achieved by aircraft within this airspace. The RNP concept for en-route operations has been approved by ICAO (Annex 11, Chapter 2) and RNP types are described in the *Manual on Required Navigation Performance (RNP)* (Doc 9613) has been extended to cover approach, landing and departure operations.

6.4 RNP alone cannot be used in the selection of separation minima, and a decision to establish route spacing and aircraft separation minima should also take into account the level of communications, surveillance and air traffic services in the airspace concerned.

6.4 RNP is a statement of navigation performance accuracy within a defined airspace based on the combination of the navigation sensor error, airborne receiver error, display error and flight technical error.

6.5 RNP types for en-route operations are identified by a single accuracy value defined as the minimum navigation performance accuracy required within a specified containment level. The en-route RNP types are described in Doc 9613.

6.6 The RNP types for approach, landing and departure operations are defined in terms of required accuracy, integrity, continuity and availability of navigation. While some RNP types contain accuracy specification of lateral performance only (i.e. similar to en-route), other types also include lateral and vertical performance specifications. The types similar to en-route specification are intended for operations such as non-precision approach or departure. Most RNP types for approach and landing operations do require vertical containment based on navigation system information.

GLOBAL NAVIGATION SATELLITE SYSTEM (GNSS)

6.7.5 The GNSS is a worldwide global position and time determination system, which includes one or more core satellite constellations, aircraft receivers, and system integrity monitoring, and augmented augmentation systems that enhance performance of the core constellations as necessary to support the RNP for the actual phase of operation.

6.8.6 The satellite navigation systems in operation are the global positioning system (GPS) of the United States and the gLObal-orbiting navigation sSatellite sSystem (GLONASS) of the Russian Federation. Both systems were offered to ICAO as a means to support the evolutionary development of GNSS. In 1994, the ICAO Council accepted the United States' offer of the GPS, and in 1996 it accepted the Russian Federation's offer of GLONASS.

6.9.7 The **nominal** GPS space segment is composed of twenty-four satellites in six orbital planes. The satellites operate 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.

6.10.8 The **nominal** GLONASS space segment consists of twenty-four operational satellites and several spares. GLONASS satellites orbit at an altitude of 19 100 km with an orbital period of 11 hours and 15 minutes. Eight evenly spaced satellites are arranged in each of the three orbital planes, inclined 64.8 degrees and spaced 120 degrees apart.

GNSS AUGMENTATIONS

6.11.9 To overcome inherent system limitations and to meet the **satisfy aviation** performance requirements (accuracy, integrity, availability and continuity of service) for all phases of flight **and to enable a degree of independent monitoring**, GPS and GLONASS require varying **degrees levels** of augmentation. Augmentations are classified in three broad categories: aircraft-based, ground-based and satellite-based (see Table I-6-1).

Aircraft-based augmentations

6.12.10 Aircraft-based augmentation system (ABAS) integrates the information obtained from **GNSS with other information available on board the aircraft**. One ~~type of aircraft-based augmentation (ABAS) is called~~ **form of ABAS is** receiver autonomous integrity monitoring (RAIM), which ~~can be used if there are more than four satellites with suitable geometry in view. With five satellites in view, five independent positions can be computed. If these do not match, it can be deduced that one or more of the satellites are giving incorrect information. If there are six or more satellites in view, more independent positions can be calculated and a receiver may then be able to identify one faulty satellite and exclude it from the position determination calculations.~~ **uses only characteristics inherent in the core GNSS constellation. If signals of more than four satellites with suitable geometry are received, RAIM makes use of the redundant information to provide an integrity check.**

6.13.11 Other aircraft-based augmentations can also be implemented and are usually termed aircraft autonomous integrity monitoring (AAIM). An inertial navigation system, for example, can aid GNSS during short periods when the satellite navigation antennas are shadowed by the aircraft during manoeuvres or during periods when insufficient satellites are in view. Augmentation techniques particularly useful for improving availability of the navigation function also include altimetry-aiding, more accurate time sources or some combination of sensor inputs combined through filtering techniques.

Ground-based augmentations

6.14.12 For ~~g~~**G**round-based augmentation systems (GBAS), ~~a monitor is located at or near the airport, where~~ **supports precision approach operations, and can also support area navigation in the terminal area as necessary are desired. Signals** It includes **two or more reference receivers that monitor satellite signals. GBAS broadcast signals** are sent directly to the aircraft in the vicinity (approximately 37 km (20 NM)). These signals provide corrections to **locally** increase the position accuracy ~~locally along with~~ **and**

provide satellite integrity information. This capability requires data link(s) between the ground and the aircraft a VHF ground-to-air data broadcast channel. Standards for a ground-based system which can provide an area navigation service in a larger area are under development (ground-based regional augmentation system (GRAS)).

Satellite-based augmentations

~~6.15.13~~ It is not practical to provide coverage with ground-based systems for all phases of flight. One way to provide augmentation coverage over large areas is to use satellites to transmit augmentation information. This is known as satellite-based augmentation (SBAS). **Satellite-based augmentation system (SBAS)** provides augmentation coverage over large areas. SBAS uses a network of monitoring stations to collect information about the signals from each of the navigation satellites and broadcasts differential corrections and integrity data over a wide area using geostationary satellites.

~~6.16~~ The provision of satellite-based augmentation by geostationary satellites has certain limitations and therefore **in many cases** cannot be expected to support all phases of flight, especially precision approach and landing of higher categories. Since these satellites orbit above the equator, their signals would not be available in polar regions and may be masked by aircraft structure or terrain. This suggests that other GNSS augmentation satellite orbits and/or ground-based augmentation might need to be considered to alleviate these shortcomings **for certain regions or operations**.

FUTURE GNSS SIGNALS AND THEIR COMBINED USE

6.14 GPS and GLONASS are being enhanced to provide additional signals on protected frequencies. GALILEO is being developed to provide an additional constellation of navigation satellites also providing multiple signals on several frequencies. The increasing number of GNSS signals and constellations has the potential to offer significant benefits to civil aviation including improved performance and robustness, GNSS ground architecture simplification and alleviation of institutional concerns. The introduction of these new elements also raises some technical and institutional issues. As these future signals and system elements are developed, ICAO will provide guidance to States as to how to best make use of these additional signals and elements in combination and to maximize the opportunities from the capabilities being offered.

AVIONICS

~~6.17.15~~ Simple GPS or GLONASS **GNSS** receivers that do not include ~~RAIM~~ **ABAS, SBAS or GBAS** capability (or similar future forms of integrity monitoring) generally cannot meet the **aviation navigation** requirements for all phases of flight.

~~6.18.16~~ Multi-sensor systems, using GNSS as one of the sensors, are expected to be in **use operation** for the foreseeable future. Such navigation systems ~~generally exhibit better levels of~~ **more reliable** performance than the individual sensor or stand-alone systems. Aircraft using multi-sensor navigation systems, such as integrated ~~GNSS/IRS or GNSS/IRS/FMS~~, may be certified as meeting levels of RNP **combinations**

of GNSS, IRS and DME, may provide higher service availability which could not be obtained by use of GPS or GLONASS alone.

~~WGS-84 COORDINATE SYSTEM AND~~ ~~AERONAUTICAL DATABASES~~ **COORDINATE DATA**

6.19.17 The successful global implementation of satellite navigation is predicated on the existence of a coordinate and procedures database of a very high ~~quality~~ **accuracy and integrity**. ~~Accurate~~ **Reliable** satellite navigation is only possible when the ~~ground-derived~~ **derived from the navigation database of waypoints are of the required quality** ~~calculated coordinates, and the satellite system-derived coordinates use the same geodetic reference system.~~

6.20.18 In support of evolving ~~navigation techniques~~ **satellite-based technology**, ICAO adopted WGS-84 as the common geodetic reference datum for civil aviation with an applicability date of 1 January 1998 (Annex 15). Implementation of WGS-84 involves, among other things, the **possibility of coordinate conversion for non-critical points (e.g. obstacles en-route) and preferred resurveying of all critical points needed to high quality (e.g. runway threshold)** ~~transformation of existing coordinates and reference datums to WGS-84.~~

6.21.19 Aeronautical databases are built and updated through the use of surveys of existing navigation aids, position fixes and runway thresholds and through the design of new routes or approach procedures. Systems are to be in place to ensure the ~~quality (accuracy, integrity and resolution)~~ of position data from the time of the survey, to the submission of information to the next intended user. Aeronautical databases must be updated on a regular basis.

EVOLUTIONARY INTRODUCTION

6.22.20 GNSS implementation will be carried out in an evolutionary manner, allowing gradual system improvements to be introduced. Near-term applications of GNSS are intended to enable the early introduction of ~~satellite-based en-route~~ **area navigation without any infrastructure investment**, using the ~~existing core satellite systems~~ **constellations (GPS and GLONASS) and primarily aircraft-based augmentations integrated multisensor airborne systems**. The use of these systems already allows for increased reliability of non-precision approach operations at some airports.

6.23.21 ~~Medium-term~~ **Other** applications will make use of existing satellite navigation systems with ~~any~~ **some type of** augmentation, or combination of augmentations required for operation in a particular phase of flight. Longer-term applications will apply to future GNSS.

6.24.22 Three levels are generally accepted for the introduction of GNSS-based operations:

- a) ~~supplemental means GNSS must meet accuracy and integrity requirements for a given operation or phase of flight; availability and continuity requirements may not be met. Other navigation systems supporting a given operation or phase of flight must be on board;~~

-
- ~~b) primary means GNSS must meet accuracy and integrity requirements, but need not meet full availability and continuity of service requirements for a given operation or phase of flight. Safety is achieved by limiting operations to specific time periods and through appropriate procedural restrictions. Other navigation systems can be retained on board to support the primary means GNSS;~~
 - ~~c) sole means GNSS must allow the aircraft to meet, for a given operation or phase of flight, all four requirements: accuracy, integrity, availability and continuity of service.~~

GNSS-based operations can be approved with a variety of operational procedures, depending on the GNSS level of service and the operational requirements. These procedures can be very specific, either to particular types of aircraft (based on equipage), the type of operation (e.g. non-precision approach), any unique characteristics of the operation (e.g. ability to conduct approaches along curved path segments), or a specific location (e.g. airspace with low traffic density). Periods of system unavailability must be operationally managed through NOTAMs or an equivalent notification to the users. Some States have approved the use of GNSS where the user is responsible for deciding if there is an operationally significant outage.

SYSTEMS TO SUPPORT APPROACH, LANDING AND DEPARTURE OPERATIONS

Editorial Note.— Original paragraph 6.25 has been moved and modified. It is now paragraph 6.28.

6.26.23 ~~The terminology in 6.24 applies to the required state of avionics equipage and the ability of aircraft to meet RNP requirements with, in case of “sole means”, no other navigation equipment on board. It is also related to the intended operation (or phase of flight). Operational approvals for aircraft are therefore issued for particular operations and normally identify specific conditions or restrictions to be applied. To this end they may vary from State to State, and from operation to operation.~~

6.27.24 ~~GNSS sole means approval may facilitate is therefore a necessary, but not sufficient, condition for termination of present the withdrawal of specific conventional ground-based radio navigation services. The withdrawal of ground-based navigation services should, however, be undertaken with due consideration to the need for and methods of mitigating GNSS vulnerabilities (see 6.27). A number of aircraft may be approved for sole means GNSS navigation for particular operations or phases of flight. However, The air traffic navigation service provider must then provide a navigation service to all users concerned to support all-relevant phases of flight without reliance on any conventional ground-based means of navigation. It is therefore necessary to harmonize any withdrawal of conventional nav aids with the introduction of GNSS navigation service. These considerations are not applicable to airspace where present nav aids conventional ground-based navigation aids are currently not available and GNSS alone can be introduced to benefit GNSS-equipped users.~~

~~6.28.25~~ When introducing GNSS-based services, each State shall identify the elements of GNSS that are provided **are to be approved** (e.g. GPS, GLONASS, SBAS, GBAS **and augmentation systems**) and develop an implementation plan. ~~Where navigation services such as VOR, DME and ILS already exist, States could credit the economic savings associated with the decommissioning of ground-based navigational aids.~~ The cost of implementing SBAS and GBAS should be tied to the provision of user benefits and increased airspace efficiency associated with area navigation and the potential to support lower decision altitude/height to more runways. **Where navigation services such as VOR, DME and ILS already exist, States could credit the economic savings associated with the decommissioning of ground-based navigational aids although the costs associated with the transition need to be fully understood and taken into account.**

~~6.29.26~~ Advantages of GNSS ~~services~~ include the ~~use of GPS/ABAS~~ **provision of navigation service** for en-route ~~and through~~ non-precision approach operations where the coverage of ground-based navigation aids does not exist or is limited. In such an environment, GNSS ~~would become~~s the only navigation service as soon as it is introduced. ~~SBAS-based precision approach capability~~ **Approaches with GNSS-based vertical guidance** to runways that currently only have a non-precision approach ~~capability~~ will provide further advantages in terms of increased safety and operational efficiency.

~~6.30~~ Several technical concerns have been raised with respect to the reliance on GNSS services. Principal among them is the possibility for intentional interference, or jamming, that has the potential to disrupt GNSS navigation services over relatively large areas. States and air navigation service providers should develop plans to reduce the likelihood of such occurrences, to detect and eliminate sources of interference and to ensure that aircraft can continue to operate safely during periods when GNSS signals are disrupted. Depending on the traffic density in a given airspace and the degree of integration and automation of the air navigation system, a safety assessment might demonstrate the need for navigational information derived from different independent sources to address certain threats such as intentional jamming.

~~6.31~~ Other risk areas are expected to be mitigated as GNSS continues to evolve to a more comprehensive service, such as the introduction of additional signals for aeronautical use on GPS and GLONASS satellites, augmentation system improvements, and the introduction of additional satellites and satellite systems. Each State will have to evaluate the effectiveness of the mitigation techniques applied in its airspace to determine if it is acceptable to rely on GNSS alone for the provision of navigation service.

MITIGATION OF GNSS VULNERABILITIES

6.27 A number of GNSS vulnerabilities have been identified, in particular the risk of intentional interference or jamming. Adequate mitigations have been identified, including use of inertial navigation systems, procedures, and terrestrial aids. Additional mitigations will be available with the provision of new GNSS signals and constellations. States should assess the vulnerability for their airspace and select mitigations depending on the nature of the air traffic in the airspace in question and the operations that must be supported. The appropriate mitigations will ensure safe operations in the transition to GNSS and enable States to reduce existing terrestrial navigation aids, avoid the provision of new terrestrial navigation aids, and discontinue them in certain regions. To date, no vulnerabilities have been identified that could not be addressed by appropriate mitigation methods thus confirming the ultimate goal of transition to GNSS as a global system for all phases of flight.

SYSTEMS TO SUPPORT APPROACH, LANDING AND DEPARTURE OPERATIONS

6:25.28 The standard non-visual aids for precision approach and landing are defined in Annex 10, Volume I, Chapter 2. It is intended that the introduction and application of these non-visual aids will be in accordance with the global strategy set forth in Annex 10, Volume I, Attachment B. This strategy ~~will~~ **is to:**

- ~~—— a) — continue ILS operations to the highest level of service as long as operationally acceptable and economically beneficial;~~
 - ~~—— b) — implement MLS where operationally required and economically beneficial;~~
 - ~~—— c) — promote the use of multi-mode receivers (MMR) or equivalent airborne capability to maintain aircraft interoperability;~~
 - ~~—— d) — validate the use of GNSS, with such augmentations as required, to support approach and departure operations, including Category I operations, and implement GNSS for such operations as appropriate;~~
 - ~~—— e) — complete feasibility studies for Category II and III operations, based on GNSS technology, with such augmentations as required. If feasible, implement GNSS for Category II and III operations where operationally acceptable and economically beneficial; and~~
 - ~~—— f) — enable each region to develop an implementation strategy for future systems in line with the global strategy.~~
- a) continue ILS operations to the highest level of service as long as operationally acceptable and economically beneficial;
 - b) implement MLS where operationally required and economically beneficial;
 - c) implement GNSS with augmentation as required for APV and Category I operations where operationally required and economically beneficial;
 - d) promote the development and use of a multi-modal airborne landing capability;
 - e) promote the use of APV operations, particularly those using GNSS vertical guidance, to enhance safety and accessibility;
 - f) identify and resolve operational and technical feasibility issues for GNSS with ground-based augmentation system (GBAS) to support Category II and III operations. Implement GNSS for Category II and III operations where operationally required and economically beneficial; and
 - g) enable each region to develop an implementation strategy for these systems in line with the global strategy.

...

GENERAL TRANSITION ISSUES

6.32.29 Guidelines for transition to the future systems encourage equipage by users for the earliest possible accrual of systems benefits. Provision and carriage of terrestrial and satellite-based navigation equipment are required during the transition period when the reliability and availability of a new system must be proven. Appendix A to this chapter lists the guidelines that States, regions, users, service providers and manufacturers should consider when developing GNSS or when planning for its implementation.

APPENDIX A TO CHAPTER 6

GUIDELINES FOR TRANSITION TO NAVIGATION SYSTEMS

- GNSS should be introduced in an evolutionary manner, with **improvements in GNSS capability generating** increasing benefits, ~~commensurate with improvements in navigation service. These benefits should~~ **and culminate**ing in GNSS ~~sole means operations.~~ **supporting all phases of flight. As GNSS evolves, the planning for the removal of ground-based navigation aids should take account of the issues described below:**
- The ground infrastructure for current navigation systems must remain available during the transition period.
- States/regions ~~should~~ **can** consider segregating traffic according to navigation capability and granting preferred routes to aircraft with better navigation performance **where this can be done without reducing airspace capacity.**
- **Before any existing ground infrastructure is considered for removal, users shall be given reasonable transition time to allow them to equip with GNSS to attain equivalent navigation service.**
- **As GNSS is introduced for enroute operation,** States/regions should coordinate to ensure that **harmonized separation standards and procedures are developed and introduced concurrently in all flight information regions along major traffic flows to allow for a seamless transition to GNSS-based navigation** ~~for appropriately equipped aircraft are introduced approximately simultaneously in each FIR through which major traffic passes.~~
- In planning the transition to GNSS, the following issues must be considered:
 - a) **maintaining or improving the current level of safety;**
 - ~~a~~b) schedule for provision and/or adoption of a GNSS service, including aircraft and operator approval processes;
 - ~~b~~c) extent of existing ground-based radio navigation services;

- ed) strategy for transition schedule to GNSS capability (i.e. benefits-driven or mandatory);
- de) appropriate level of user equipage with GNSS capability;
- ef) provision of other air traffic services (i.e. surveillance and communications);
- fg) density of traffic/frequency of operations; and
- gh) mitigation of risks associated with radio frequency interference; and
- i) design and implementation of procedures.

...

Chapter 12 ORGANIZATIONAL AND INTERNATIONAL COOPERATIVE ASPECTS

...

Global Navigation Satellite System (GNSS)

12.11 The GNSS will initially be composed of a satellite systems that provides standard positioning service and system augmentations, which may either have wide area or local area coverage. System augmentation is required for meeting certain performance requirements criteria that may be imposed. Positioning signals are being offered free of charge by the two provider States concerned: at least up to the year 2010 by the Russian Federation (the GLONASS system) and, for the foreseeable future, with six years' advance notice of any change to that policy, by the United States (the GPS system). Both these systems are originally military systems, which are being made available for civilian use. Unless these systems are replaced by (civilian) systems requiring financial commitments from the civil establishment worldwide, the provision, as opposed to the use, of the standard positioning service does not appear to be dependent on organizational issues needing to be addressed by States other than the two provider States. The GALILEO core satellite constellation, being developed by the European Union member States, is intended to be a civil controlled and operated system designed to fulfil the requirements of a variety of users including civil aviation. Similar to GPS and GLONASS, GALILEO Open Service will provide a positioning service to aviation free of direct user charges.

12.12 Systems augmentation gives rise to somewhat different considerations. For example, wide area SBAS augmentation could be provided by the same State(s) or entity that operates a core satellite constellation providing global standard positioning service. However, a group of States or a regional organization might also undertake to operate the augmentation satellite service required, either by themselves or by contracting with a commercial or government organization to do so on their behalf. Thus, the same type of options as outlined in 12.8 above apply. In each instance, costs would be incurred that would presumably need to be recovered. From an organizational point of view, such augmentation would in fact be a multinational facility or service to which the guidance material on the provision and operation of multinational facilities and services, which is addressed later in this chapter, could apply, as long as the augmentation is primarily to serve civil aviation. On the other hand, if civil aviation is only going to be a minority user of the

augmentation services provided, and the entity will provide augmentation services worldwide, a joint concerted approach through, for example, ICAO, a regional air navigation services providers association, or an international aviation user association, for dealing with the service provider, may be the most appropriate.

12.13 Augmentation with local coverage would most likely not require international involvement provided that the facility meets the specifications and Standards required for it to be listed as an international civil aviation facility. The facility itself could be provided by the national or local government or under contract by a commercial entity.

12.14 To capture the benefits associated with GNSS, the implementation of RNAV is essential. This will require a harmonized approach to the implementation of RNP and RNAV.

...

— END —