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Acta Astronautica 54 (2004) 961–963
ACTA ASTRONAUTICA
www.elsevier.com/locate/actaastro

Development of standards for aeronautical satellite navigation system

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Abstract

One of the work objectives of the International Civil Aviation Organisation (ICAO) is the development of the standards and procedures necessary to support transition to the CNS/ATM systems, which include Global Navigation Satellite System (GNSS). The Global Navigation Satellite System Panel (GNSSP) was established by the ICAO Air Navigation Commission in 1993 with the basic objective to develop ICAO standards and recommended practices (SARPs) and guidance material as required to support aeronautical GNSS applications world-wide. The first package of GNSS SARPs was adopted and published by ICAO in 2001, and further work is under way to introduce new satellite constellations and system elements in an evolutionary fashion.

1. Introduction

As the specialized agency of the United Nations International Civil Aviation Organisation (ICAO) responsible for international civil aviation, the Organisation sets the Standards and Recommended Practices (SARPs) for the safe and orderly development of international civil aviation world-wide. This include SARPs for various components of the Communication, Navigation, Surveillance (CNS)/Air Traffic Management (ATM) concept.

In the early 1980s, the ICAO Council established the special committee on Future Air Navigation Systems (FANS) to develop recommendations for the future development of air navigation for civil aviation over a period of the order of 25 years. In September 1991, the ICAO 10th Air Navigation Conference endorsed the FANS Concept. After acceptance by the ICAO Council, it came to be known as "communications, navigation, and surveillance/air traffic management (CNS/ATM) systems".

In order to progress implementation of CNS/ATM systems, ICAO developed the document, now known as the Global Air Navigation Plan for CNS/ATM Systems (ICAO Global Plan) as a strategic document to guide the implementation of CNS/ATM systems.

2. Development of SARPs

The ICAO Global Plan recognises the Global Navigation Satellite System (GNSS) as a key element of CNS/ATM systems, which can provide seamless navigation for all phases of flight, and a foundation upon which States can deliver improved aeronautical navigation services. The ICAO policy on GNSS states that the system should be implemented as an evolutionary progression from existing global navigation satellite systems, including the United States' GPS and the Russian Federation's GLONASS, towards an integrated GNSS over which Contracting States exercise a sufficient level of control on aspects related to its

0094-5765/$ - see front matter © 2003 Published by Elsevier Ltd.
doi:10.1016/j.actaastro.2004.01.039

use by civil aviation. Further, it states that ICAO shall continue to explore, in consultation with Contracting States, airspace users and service providers, the feasibility of achieving a civil internationally controlled GNSS.

In line with the policy, ICAO work on GNSS covers a wide variety of issues including institutional and legal issues, economics, operational procedures and criteria, and technical standardisation. To progress work in the latter area, the ICAO Air Navigation Commission established, in 1993, the Global Navigation Satellite System Panel with the basic objective to develop ICAO Standards and Recommended Practices (SARPs) and guidance material as required to support aeronautical applications of GNSS world-wide. The first package of GNSS SARPs as developed by the Panel was published in Annex 10 to the Chicago Convention on International Civil Aviation and became applicable as of 1 November 2001.

Unlike previously developed standards for terrestrial radio navigation aids in Annex 10, GNSS SARPs are split into two parts:

- basic provisions specifying system level, functional and performance requirements; any amendments to this part of SARPs are subject to regular ICAO procedure involving consultation with States; and
- detailed technical specifications which can be amended through abbreviated procedure not involving States.

Basic provisions establish GNSS as a standard aid to aeronautical navigation and to instrument approach and landing, define high level system requirements and set forth protection dates for system elements and satellite navigation services.

Detailed technical specifications also have a status of SARPs, however abbreviated procedure for changes was adopted by the ICAO Assembly to avoid time and resource consuming consultation with States on amendments not affecting system functionality and performance. The abbreviated procedure also facilitates amendments to SARPs needed to take account of the evolution of complex systems such as GNSS.

System evolution and resulting compatibility issues are the matter of particular concern in case of GNSS, and this concern is addressed in SARPs through the introduction of protection dates. To enable system evolution, incremental system modifications and respective amendments to GNSS SARPs will be required, and some of them may affect backward compatibility of GNSS elements. In accordance with SARPs such amendments can be introduced and published in Annex 10 at least 6 years prior to the date when they are realised in the system and put into operation. Further, possible discontinuation of GNSS services provided by its various elements is covered by the standard which permits the termination of a GNSS service on the basis of at least 6-year advance notice made by a service provider.

It is well known that the existing navigation satellite constellations alone do not meet aviation requirements particularly in terms of accuracy and integrity. To satisfy these requirements, three forms of augmentations were established in SARPs, namely Aircraft-Based Augmentation System (ABAS), Satellite-Based Augmentation System (SBAS) and Ground-Based Augmentation System (GBAS).

Accordingly, current GNSS standards define the following system elements:

- GPS
- GLONASS
- ABAS
- SBAS
- GBAS
- GNSS receivers

The first package of GNSS SARPs was developed to support navigation in en-route phases of flight, operations in terminal areas and precision approach and landing operations down to the 60 m (200 ft) decision height and the 800 m visibility (Category I precision approach).

Among other challenges in the course of SARPs development, the definition of GNSS performance levels that meet the requirements of specific phases of flight and operations was a major one. While offering significant advantages over terrestrial systems, the satellite technology has limitations and brings with it a number of new issues such as effects of GNSS service interruptions on the air traffic control system. Another challenge is strict integrity monitoring requirements, which are particularly stringent for all weather approach and landing operations.

The final set of parameters defining system performance levels in GNSS SARPs includes accuracy (horizontal and, where required, vertical), integrity, time-to-alert, continuity and availability.

The largest part of SARPs contains technical specifications for each element of the system including RF characteristics, coverage definitions, message data content, protocols for data applications monitoring and basic receiver functions and interference immunity. Specifications for core satellite constellations are limited to those considered to be critical for the design of interoperable augmentations, and extensive specifications for SBAS and GBAS are built upon them.

Standardisation of future elements of GNSS has begun and will be progressed by the GNSS Panel depending upon research and development in States and industry organisations. Current programme of the GNSS Panel in the standardisation work area contains:

- GPS L5 signal;
- GALILEO;
- Ground-based Regional Augmentation System (GRAS—a wide-area configuration of GBAS);
- GLONASS-M;
- Category II/III GBAS; and
- GNSS architectures to support aerodrome surface operations, guided take-off, curved approaches.

In the course of this future work, GNSS spectrum issues such as interference and frequency protection need to be followed up with great attention. Still to be developed, capability of GNSS to support all weather operations would be undermined in case of unfortunate developments in this area resulting in devaluation of GNSS as a global navigation system for all phases of flight.

3. Conclusions

Present GNSS SARPs and guidance material on their application in ICAO Annex 10 (Volume I of the annex) provide comprehensive definition of GNSS, which will serve aviation for years to come until new civil signals and elements are designed and become available for general use.

Transition to satellite navigation brings about new or more demanding requirements for aeronautical data bases, common geodetic reference, protection of frequency bands raising the issues that cannot be easily resolved and implemented world wide. These challenges affect the initially envisaged time frames for introduction of GNSS-based aircraft operations. It has to be recognised that the transition to satellite navigation cannot be accomplished over a short term and will require a long-term commitment.

While navigation service providers gradually and continually improving the air navigation infrastructure through the introduction of initial GNSS-based capabilities, the Global Air Navigation Plan for CNS/ATM systems maintains the vision of GNSS as a salient feature of ICAO navigation policy. Some elements of the policy need to be reviewed in the light of more than a decade of GNSS development and implementation activities that have taken place since the ICAO 10th Air Navigation Conference in 1991. This task will be undertaken by the 11th AN Conference (22 September–3 October 2003), which will review, among other CNS/ATM issues, up-to-date information on GNSS status, its future architecture and levels of service that could be provided at the various stages of system evolution. In light of this information, the conference would also assess the role of terrestrial radio navigation aids and conclude with updated guidelines for transition to satellite navigation.