AN-Conf/11-WP/183
23/9/03

ELEVENTH AIR NAVIGATION CONFERENCE

Montreal, 22 September to 3 October 2003

(DRAFT) REPORT OF COMMITTEE B ON AGENDA ITEM 6

The attached draft which constitutes a part of the report on Agenda Item 6 (sub-item 6.1) is presented for approval by Committee B for submission to the Plenary.

(8 pages)

Agenda Item 6 : Aeronautical navigation issues

6.1 GLOBAL NAVIGATION SATELLITE SYSTEM (GNSS) DEVELOPMENT STATUS BASED ON REPORTS FROM STATES, SERVICE PROVIDERS AND INDUSTRY ORGANIZATIONS

6.1.1 Introduction

6.1.1.1 When inviting States and international organizations to the Eleventh Air Navigation Conference (State letter ST 12/1-02/58 refers), ICAO drew particular attention of States, service providers and organizations involved in the development of GNSS and its elements to the need for providing, under Agenda Item 6, relevant supporting information on these activities.

6.1.1.2 In response to ICAO's request, a number of States and service providers presented to the meeting information concerning modernization of the Global Positioning System (GPS) and GLObal NAVigation Satellite System (GLONASS) and development of the new core satellite constellation GALILEO. The conference was also informed of the status of satellite-based augmentation system (SBAS) in the United States, Europe, Japan and India. Also presented were the reports concerning ground-based augmentation system (GBAS) and ground-based regional augmentation system (GRAS).

6.1.1.3 The conference reviewed information in the following order: core satellite constellations, satellite-based augmentation systems and ground-based augmentation systems.

6.1.2 Core satellite constellations

GPS

6.1.2.1 The conference noted that the space segment of the Global Positioning System (GPS) consisted of twenty-eight satellite in operational status. The conference was informed that the United States had developed a plan for the modernization of GPS. One of the principle objectives of modernization is to provide additional coded civil signals. A second civil signal, known as L2C will be broadcast at the 1227.6 MHz frequency, and a third civil signal, known as L5, will be at 1176.45 MHz. The new, more robust civil code to L2 will begin in 2004. The addition of a third civil signal (L5) designed for aviation and other safety-of-life uses will be available beginning in 2006. Based on the current 2004 budget schedule, an initial operational capability for dual frequency navigation will occur in 2010 (calendar year), based on a constellation of 18 satellites broadcasting the new civil code on L2. Similarly, the L5 signal should be available on 18 GPS satellites by late 2013.

GLONASS

6.1.2.2 The conference noted that the space segment of the GLONASS system at the time of the meeting consisted of 11 satellites, eight of which operated without restrictions. The conference was informed that, in August 2001, the Government of the Russian Federation had adopted a ten-year federal special programme for maintaining and further developing GLONASS. The programme includes the development of the new-generation satellite GLONASS-M which will be launched for the first time together with two GLONASS satellites in the fourth quarter of 2003. Further evolution will include the development of an advanced satellite GLONASS-K with a lifetime of 10 to 12 years, improved accuracy performance and an additional navigation signal in the band 1 164 - 1 215 MHz. The GLONASS-K satellite will be considerably lighter than existing versions, making it possible to reduce by several times the costs of deploying and maintaining the orbital segment of the system.

6.1.2.3 Deployment of the orbital segment will be phased as follows:

Phase 1: In 2006 the orbital segment will be increased to 18 satellites, some of which will be GLONASS-M satellites with an increased lifetime and improved performance.

Phase 2: After 2006 the orbital segment will be deployed and maintained at the level of 24 satellites by launching GLONASS-K satellites.

6.1.2.4 It was also reported that gradual transfer of system operation to lower portions of the currently occupied bands would continue in accordance with the existing agreements to secure eletromagnetic compatibility with the Radioastronomy and Mobile Satellite Service.

GALILEO

6.1.2.5 The conference was informed that European States, recognizing the strategic importance of satellite navigation, its potential applications and the current GNSS shortcomings, had decided to develop a European GNSS capability in a two-step approach through the implementation of an SBAS known as European Geostationary Navigation Overlay Service (EGNOS) to cover the short and medium term needs, and of a satellite navigation constellation (GALILEO) to support multimodal user needs for the longer term. The GALILEO program will deploy a full European satellite constellation, under civil control, that will strengthen the robustness of satellite navigation, alleviate a number of institutional concerns and should further facilitate a full transition to satellite navigation. The GALILEO stakeholders had already established and support further international and bilateral cooperation in the system development. The use of the services offered by GALILEO would rely on the availability of ICAO Standards.

6.1.2.6 Alongside an open service similar to the Standard Positioning Service (GPS), GALILEO would offer new features to improve and guarantee services supporting for critical, safety of life, or commercial applications. GALILEO services would be required to be fully compatible and interoperable at the user level with other GNSS services, with no common failure mode between systems. The combined use of GALILEO and other GNSS elements would offer better performances for all users worldwide.

6.1.2.7 The GALILEO satellite-only services would be provided worldwide and independently from other systems by combining the signals broadcast by the GALILEO satellites. There was a wide range of possible applications with different operational requirements that had been grouped around five reference services: GALILEO Open Service (OS), Safety of Life (SoL), Commercial Service (CS), Public Regulated Service (PRS) and Support to Search and Rescue (SAR).

6.1.2.8 The meeting noted that the GALILEO preliminary system design phase was completed and that the European Space Agency (ESA) was preparing development contracts for deployment of the infrastructure, including the launching of the first test satellites.

6.1.2.9 The GALILEO infrastructure would be implemented in three phases:

a) development and validation phase (2002-2005);

b) deployment phase (2006-2007); and

c) operational phase (from 2008).

6.1.3 **Satellite-based augmentation system (SBAS)**

WAAS

6.1.3.1 The conference noted with appreciation that, on 10 July 2003, WAAS was commissioned for use in all phases of air navigation in the United States national airspace system (NAS) including one class of instrument approach with both lateral and vertical guidance (lateral navigation (LNAV)/vertical navigation (VNAV)). WAAS performance had consistently demonstrated 1 m horizontal and 1.5 m vertical accuracy. WAAS initial operating capability (IOC) provided users with the capability to fly approaches with vertical guidance throughout the United States NAS. This initial WAAS capability also provided improved guidance to users in the en route and departure domains. LNAV/VNAV was an approach procedure with vertical guidance with nominal minimums of a 105 m (350 ft) decision height and 1.25 mile visibility. Over 700 LNAV/VNAV procedures had been published for WAAS operations. The WAAS service area was the continental United States and portions of Alaska.

6.1.3.2 The Federal Aviation Administration (FAA) had improved the approach capability of WAAS through terminal instrument procedure optimization. This improvement consisted of a new approach procedure with vertical guidance called LPV, which was compliant with Annex 10 criteria for APV1. LPV provided lateral approach guidance performance equivalent to instrument landing system (ILS) localizer performance. This was a significant improvement over LNAV/VNAV resulting in lower approach minima for most runways. LPV procedures had nominal minimums of 75 m (250 ft) decision height and 0.5 mile visibility with proper lighting. LPV would make the vertical guidance safety benefit accessible to the general aviation community, thus directly enhancing the flying safety for general aviation aircraft and other WAAS users.

6.1.3.3 WAAS final operating capability (FOC), with LPV capability, throughout an expanded service area, was expected by December 2007. WAAS Category I precision approach capability, would await the availability of the second GPS aviation frequency, L5 (1176.45 MHz). According to the current plan, by 2013 enough GPS satellites with L5 capability would be on orbit so as to be operationally usable by aviation. The FAA plans to upgrade WAAS to use L5 prior to this time.

European Geostationary Navigation Overlay Service (EGNOS)

6.1.3.4 The meeting was informed that the EGNOS project, as implemented by the European Tripartite Group (ETG), formed by ESA, European Commission and EUROCONTROL, represented the first European contribution to the GNSS. EGNOS would provide and guarantee navigation signals for aeronautical, maritime and land mobile trans-European network applications. On behalf of the tripartite group, the European Space Agency was responsible for the system design, development and technical validation of an Advanced Operational Capability (AOC) of the EGNOS system. The technical validation was to be completed in 2004, to enable operational use of the EGNOS signal for safety-of-life applications in 2005. Possible evolution scenarios of EGNOS after 2004 were being assessed.

6.1.3.5 EGNOS would provide improved services with respect to GPS, in terms of accuracy (from 20 metres to 1 - 2 metres), service guarantee (via integrity signal) and availability (via additional ranging signals). It would operate on the GPS L1 frequency. Initial coverage would be the European Civil Aviation Conference area, and could be later extended to include other regions. EGNOS would meet, enhancing GPS and GLONASS, many of the current positioning, velocity and timing requirements of the land, maritime and aeronautical modes of transport in the European Region.

6.1.3.6 For civil aviation, EGNOS would comply with RTCA DO 229C and ICAO SBAS SARPs requirements and would provide in ECAC an aviation service from en-route through APV-2 (VAL=20m; HAL=40m).

6.1.3.7 An extension of the EGNOS service outside the core ECAC area to the (AFI) region was being conducted, initially through the deployment of an ESTB (RIMS) in the Dakar area in cooperation with the Agency for Air Navigation Safety in Africa and Madagascar (ASECNA). The follow up phase of the AFI Region work plan included the deployment of a network of RIM stations through the region and the preparation for operational implementation.

6.1.3.8 In the CAR/SAM Regions, EGNOS trials had been conducted under an ICAO technical cooperation project. To carry out the trials based on the ESTB-signal, three reference stations had been deployed in the region and connected to the ESTB. The EGNOS-type trials provided useful information in support of the GREPECAS activities in the definition of the GNSS strategy for the region. Areas of cooperation with the WAAS trials had been identified.

MSAS

6.1.3.9 The meeting recalled that, in accordance with the Future Air Navigation System (FANS) concept endorsed at Tenth Air Navigation Conference in 1991, the Japan Civil Aviation Bureau (JCAB) had been developing multi-functional transport satellite (MTSAT) and MTSAT satellite-based augmentation system (MSAS). MTSAT was designed as a geo-stationary satellite with both a meteorological and an aeronautical mission.

6.1.3.10 The aeronautical mission consists of two functions: aeronautical mobile satellite service (AMSS) and GNSS satellite based augmentation system (SBAS) to provide aircraft with GPS augmentation information uplinked from ground facilities. The MSAS function of the MTSAT would be fully compliant with the ICAO SARPs. Technical details not specified in SARPs were coordinated through the activities of SBAS Technical Interoperability Working Group (IWG). Thus, the MSAS was fully interoperable with other SBAS services.

6.1.3.11 After the launch failure of MTSAT-1 (the first MTSAT) JCAB procured an alternate satellite, MTSAT-1R which would be launched in early 2004. The second MTSAT, MTSAT-2 would be launched in 2005. After completion of the certification, MSAS would be commissioned and be operational using only MTSAT-1R from 2005. Dual operation by MTSAT-1R and MTSAT-2 would be commissioned in 2006.

6.1.3.12 Two aeronautical satellite centres would be engaged in controlling MTSATs. MSAS master control stations (MCSs) had been installed at the two aeronautical satellite centres. To provide MSAS service over the Japanese FIR, ground monitor stations (GMSs) had been installed at four air route traffic control centres. To secure a long base line for accurate orbit determination of MTSATs, two monitor and ranging stations (MRSs) were installed in Hawaii, United States and Canberra, Australia. There was also a MRS at each aeronautical satellite centre.

6.1.3.13 In normal operation, users would be able to receive two SBAS signals with different PRN codes. Each signal would be uplinked from a different MCS and through a different satellite. In the event of failure of one of the satellites, the MCS currently uplinking through the failed satellite would switch to the other satellite. Thus, even in these abnormal conditions the user avionics would still be able to receive the two SBAS signals. The conference noted that this architecture provided the assurance of highly redundant and reliable SBAS service.

6.1.3.14 Since the MSAS signal would be broadcast by MTSAT over most of the Asia/Pacific Region, the MSAS service area could be easily expanded if GMSs were installed in the MTSAT coverage area and dedicated ground lines were connected to MCSs. In this connection, the conference noted with appreciation that JCAB offered free MSAS service to the Asia/Pacific States in order to achieve a global, seamless, safer and more reliable air navigation system in this region.

GAGAN

6.1.3.15 The conference was informed by India that the Airports Authority of India (AAI) and Indian Space Research Organisation (ISRO) had jointly undertaken a programme for the development and implementation of the GPS and GEO augmented navigation (GAGAN) system, to cater to the satellite navigation augmentation requirements for aircraft operators and air traffic services (ATS) providers in the Indian airspace, including the Indian oceanic airspace, as well as large parts of the Asia/Pacific Region.

6.1.3.16 The GAGAN programme would be implemented in three phases:

a) 1st phase: **Technology demonstration systems (TDS)**: A minimum configuration system which would demonstrate the capability of the system to support up to precision approach (Category I) over a limited region of Indian airspace and would serve as a proof of concept. The TDS phase will be completed by 2005.

b) 2nd phase: **Initial experimental phase (IEP)**: In this phase TDS would be expanded to cover the entire Indian airspace and requisite redundancies would be added to the system. The IEP would be completed in a period of one year after the development of TDS.

c) 3rd phase: **Final operational phase (FOP)**: During this phase the GAGAN programme is expected to be matured. The system would be put to extensive trial operation and would be evaluated with respect to ICAO SARPs before declaring the system operational. This phase was expected to be completed in one year after IEP.

6.1.3.17 Currently, after completing a detailed payload design review, ISRO was in the process of procurement of critical components for fabrication of the navigational payload which will be put in GSAT-4 satellite to be launched in 2005 and put in 82 degree East orbital slot.

6.1.3.18 Due to the fact that India was situated close to the equator, ionospheric activities would have a significant effect on received GPS signals over Indian airspace. To adequately assess the effect of ionosphere on GPS signals and to minimize its effect, development of an ionospheric model had been initiated based on ionospheric data collected from a large number of locations over an extended period of time. Keeping this in view, it was planned to establish 20 Stations for collection of ionospheric data spread over the whole country.

6.1.3.19 The conference noted that GAGAN had been designed to meet the ICAO SARPs and to be interoperable with WAAS, EGNOS and MSAS.

6.1.4 **Ground-based augmentation system (GBAS)**

Local area augmentation system (LAAS)

6.1.4.1 The conference recalled that the local area augmentation system (LAAS) was the ground-based augmentation system (GBAS) developed by the United States to provide precision approach capability and precise position, velocity, and time (PVT) data in the terminal area (GBAS positioning service). The objective of LAAS was to provide for all categories of precision approach (PA) and landing and surface operations to suitably equipped aircraft.

6.1.4.2 The initial implementation of LAAS ground facilities would support both Category I instrument approaches and the GBAS positioning service at selected airports. The FAA awarded a contract in April 2003 for the design, development and production of the LAAS ground facility.

6.1.4.3 After validating the system design, the FAA planned to install a limited number of ground systems throughout the United States National Airspace. LAAS IOC was expected by September 2006. The FAA was currently coordinating with the aircraft operators to identify the procedures that would fully exploit the LAAS capabilities to improve airspace utilization and provide the lowest possible approach visibility minima.

6.1.4.4 The end state for LAAS is the provision of Category II/III approach and landing service, and most of the longer-term development efforts were aimed at achieving this goal. Near-term efforts were focused on achieving Category III without the use of a second frequency in the airborne receiver. This would be followed by the incorporation of the benefits from GPS modernization, in particular the additional frequency L5.

6.1.4.5 In addition, exploration of how LAAS could facilitate more efficient terminal area operations was expected to result in future LAAS applications such as guided departures, complex approach paths, guided missed approaches and surface movement guidance and control.

Ground-based regional augmentation system (GRAS)

6.1.4.6 The conference recalled that the ground-based regional augmentation system (GRAS) had been presented to the ICAO GNSS Panel (GNSSP) in 1999 as an alternative to SBAS and GBAS and that the GNSSP had been requested to develop SARPs for GRAS. The conference was informed that validation of draft SARPs for GRAS was being progressed with the aim of presenting the completed validation to the Navigation Systems Panel in May 2004.

6.1.4.7 Australia had built a GRAS test bed to facilitate the validation of the GRAS SARPs. GRAS differential and integrity data was being gathered using SBAS methodology but was transmitted to aircraft in the GBAS message format via a network of uplink stations using VHF broadcast. The test bed showed that GPS augmented by GRAS could provide en-route, terminal area and approach with vertical guidance navigation.

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