

ELEVENTH AIR NAVIGATION CONFERENCE

Montreal, 22 September to 3 October 2003

**REPORT OF COMMITTEE B TO THE CONFERENCE
ON AGENDA ITEM 6**

The attached report has been approved by Committee B for submission to the Plenary.

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Chairperson
Committee B

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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 four satellites 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 satellites GLONASS-M, the first of which will be launched 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 electromagnetic 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 GPS Standard Positioning Service, GALILEO would offer new features to improve and guarantee services supporting the 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 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 is 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 is 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 is compliant with Annex 10 performance requirements for APV I¹. LPV provided lateral approach guidance performance equivalent to instrument landing system (ILS) localizer performance. This represented a significant improvement over LNAV/VNAV resulting in lower approach minima for most runways. LPV procedures have 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.

¹ Annex 10, Volume I, Chapter 3, 3.7.2.4

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 evaluation of the EGNOS service outside the core ECAC area in the AFI Region was successfully being conducted, initially through the deployment of an EGNOS system test bed (ESTB) ranging and integrity monitoring stations (RIMS) in the Western and Central Africa areas by the ASECNA (Agency for Air Navigation Safety in Africa and Madagascar) in cooperation with the States involved. The follow up phase of the AFI Region work plan included the deployment of a RIMS network throughout other areas in the AFI Region and the preparation for EGNOS 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 (Working Group of the Whole) 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.

6.2 NAVIGATION POLICY ISSUES IN THE LIGHT OF PRESENT AND ENVISAGED GNSS SERVICES AND ARCHITECTURES, INTEGRATION AND BACK-UP OPTIONS

6.2.1 Introduction

6.2.1.1 The current ICAO strategy for the introduction of communications, navigation, and surveillance/air traffic management (CNS/ATM) systems envisages a gradual transition from the current terrestrial navigation infrastructure to the increased use of a satellite navigation infrastructure. The initial step of this transition has been supported by the development of ICAO Standards and Recommended Practices (SARPs) for the global navigation satellite system (GNSS) and publication of procedures and criteria for operations using Basic GNSS receiver.²

6.2.1.2 GPS was already being extensively used worldwide for aircraft navigation. This use included both Oceanic and domestic primary means en route, GPS non-precision approaches, GPS-based separation standards and area navigation (RNAV) and required navigation performance (RNP) operations. In Europe, it was being used as a means of compliance with basic RNAV (B-RNAV) requirements. SBAS was coming on-line with the commissioning of the United States' Wide Area Augmentation System (WAAS) and the introduction into operation other SBASs in Europe, Japan and India in the 2004 - 2006 time frame. GBAS developments are progressing, initially to support Category I precision approach.

6.2.2 The role of GNSS in provision of aeronautical navigation services and transition strategy considerations

6.2.2.1 The meeting received information on developments in States indicating an increasing role satellite navigation was playing in provision of air navigation services. One State presented its plans for phasing out some existing terrestrial facilities, beginning with the decommissioning of non-directional radio beacons (NDBs) as the equipage of commercial fleets and general aviation progresses. Several other States also indicated their planning for gradual decommissioning of terrestrial navaids as the reliance on satellite navigation increases.

6.2.2.2 The meeting was also informed of a common aviation position in the European region which was being developed with the participation of airspace users and air navigation service providers. The ultimate goal envisaged was a sole navigation service to be achieved with GNSS provided that this service would be proven to be safe, secure and the most cost beneficial solution.

6.2.2.3 This information was supplemented by the airline position on aeronautical navigation needs which supported GNSS as the primary radio navigation system for positioning and timing in the near future. The airspace users urged States, in close collaboration with airspace users, to move rapidly from the current

² The term "Basic GNSS receiver" designates GNSS avionics that at least meet requirements for a GPS receiver in Annex 10, Volume I, and specifications of RTCA DO-208 or EUROCAE ED-72A, as amended by FAA TSO-C129A or JAA TSO C129 (or equivalent).

ground-based system to a cost-effective, harmonized and interoperable space-based radio navigation system capable of being used in all airspace during all phases of flight. Airlines position also encouraged implementation of GNSS procedures, in a coordinated manner, with a view to achieving as soon as possible worldwide navigation capability from en-route down to at least Category I minima.

6.2.2.4 Based on the general consensus to expedite transition to satellite navigation the meeting discussed a proposal for the development of a strategy that sets the basis for transition to a future worldwide navigation service centred around the use of GNSS. It was recognized however that the *Global Air Navigation Plan for CNS/ATM Systems* (Doc 9750) and the Regional Air Navigation Plans represent strategic documents that meet the intent of such a proposal. The meeting agreed to reconfirm the transition objectives and established a set of conditions to be met in the course of transition.

6.2.2.5 The meeting addressed near-term objectives in the transition process. It was noted from information presented on the status of GNSS development that one satellite-based augmentation system, namely the United States WAAS became operational in mid-2003, and three other SBASs were planned to become operational in the 2004 - 2006 time frame. APV operations based on WAAS were being introduced, and States were making plans for introduction of these operations upon the commissioning of other SBASs.

6.2.2.6 The meeting reviewed information presented on the planned implementation of approaches with vertical guidance (APV) in some States. The programme in one State envisaged the deployment of such approaches in phases. The work being carried out with a view to complementing conventional approach and landing aids, in particular the instrument landing system (ILS), would involve:

- a) approval of non-precision approaches based on the use of ABAS;
- b) evaluation of the use of APV procedures with barometric vertical guidance; and
- c) lastly, the operational benefits provided through the use of APV approach and landing procedures with SBAS vertical guidance for all airspace users.

6.2.2.7 In addition, several States and international organizations reported on significant activities in the Caribbean, South American and African Regions to evaluate SBAS performance using WAAS and EGNOS test bed. Support to these trials rendered by service providers and preliminary results were appreciated, and the meeting agreed that these activities should be promoted.

6.2.2.8 Based on the above, a proposal was made that the airspace users should be encouraged to equip with SBAS receivers³ to take advantage of their superior performance over Basic GNSS receivers and improved service availability. Another proposal was also presented advocating the adoption of SBAS-based APV operations as a global requirement. The intent of the proposals was supported and the meeting agreed to encourage States and service providers, airspace users and the manufacturing industry to work together towards the above goals. The meeting therefore developed the following recommendation:

³ The term "SBAS receiver" designates GNSS avionics that at least meet requirements for a SBAS receiver in Annex 10, Volume I, and specifications of RTCA DO-229C, as amended by FAA TSO-C145A/146A (or equivalent).

Recommendation 6/1 — Transition to satellite-based air navigation

That:

- a) ICAO continue to develop as necessary provisions which would support seamless GNSS guidance for all phases of flight and facilitate transition to satellite-based sole navigation service with due consideration of safety of flight, technical, operational and economics factors;
- b) air navigation service providers move rapidly, in coordination with airspace users, with a view to achieving, as soon as possible, worldwide navigation capability to at least APV I performance; and
- c) States and airspace users take note of the available and upcoming SBAS navigation services providing for APV operations and take necessary steps towards installation and certification of SBAS capable avionics.

6.2.3 GNSS vulnerabilities and sole navigation service

6.2.3.1 The meeting was presented with a navigation strategy for the area of the European Civil Aviation Conference (ECAC) Member States which identified a transition to an area navigation (RNAV) environment supported by global navigation satellite system (GNSS). Consideration of the costs of the transition to such an environment together with the need to ensure failure survival indicated that there would, for the foreseeable future, remain a need for ground-based navigation aids and the consequent requirement to ensure continued spectrum protection for these aids.

6.2.3.2 Having agreed that spectrum availability aspects of the strategy should be addressed, as necessary, under its Agenda Item 5, the meeting discussed the GNSS potential to become the sole navigation service. The discussion focussed on some uncertainties that remain in respect to the GNSS potential to become the sole navigation service due to its potential failure modes, their corresponding impact on the ATM operations of the ECAC Member States, and mitigation possibilities.

6.2.3.3 The meeting was made aware that the Global Positioning System (GPS) without any augmentation had already been accepted as a means of providing a basic RNAV capability en-route throughout the ECAC area. This has been possible because of the ability to revert to conventional navigation using ground navigation aids such as VOR/NDB. The availability of GALILEO as a second satellite system complementing GPS, both having additional navigation signals, was expected to allow further reliance upon GNSS, thereby enabling VOR/NDB decommissioning and relying upon RNAV based upon GNSS and DME.

6.2.3.4 However, whilst the GPS plus GALILEO might provide the basis upon which a total RNAV environment might be predicated, it had still to be proven that such a solution would be cost effective in the light of the potential need for carrying dual RNAV systems to meet continuity and availability requirements. Since many aircraft were equipped with only single RNAV or flight management system (FMS) equipment, the timescale by which a cost-effective transition to a total RNAV environment could therefore be considerably extended.

6.2.3.5 Studies in the ECAC area had suggested that, as a reversionary option for the interim 2010 - 2015 time-scale, it might be more cost-effective to ensure the required level of continuity-of-service by retaining the current VOR environment to support reversionary navigation using dual VOR avionics installations on the aircraft than it would be with dual RNAV/FMS equipment and dual sensor input. If these initial results were confirmed, the expected decommissioning of VOR in that period might not be possible.

6.2.3.6 Having reviewed this information, the meeting recognized that future developments were expected to considerably reduce the risks associated with a sole GNSS service. Whilst GNSS is expected to be used for all phases of flight, some failure modes would remain that could prevent a total reliance upon GNSS. It was noted that in the context of operations within the ECAC area, there was work on-going to identify means and associated mitigation strategy by which a gradual move towards sole service might become possible. However, the ability to reach that ultimate objective and the time-scale are still uncertain and must be addressed urgently..

6.2.3.7 The meeting then reviewed the results of GNSS vulnerability study carried out by the Global Navigation Satellite System Panel (GNSSP) at the request by the Air Navigation Commission. It was observed that studies had been carried out over the recent years by several highly qualified institutions addressing GPS vulnerabilities while the report presented to the meeting attempted to consider same issues in the context of GNSS, GPS being one of the core elements of GNSS. Various vulnerabilities of GNSS, evaluation of operational risks, means of prevention of system outages and guidance on mitigation of such outages were presented and appreciated.

6.2.3.8 The conclusion of the study that, to date, no vulnerabilities had been identified that compromise the ultimate goal of transition to GNSS as a global system for all phases of flight was noted by the meeting, with the understanding that the assessment of GNSS vulnerability aspects and mitigation alternatives should continue. It was agreed that States were responsible for developing appropriate mitigation techniques for GNSS outages and that the study results presented to the meeting could serve as useful guidance for States in assessing the GNSS vulnerability and selecting appropriate mitigations. The meeting therefore developed the following recommendation:

Recommendation 6/2 — Guidelines on mitigation of GNSS vulnerabilities

That States in their planning and introduction of GNSS services:

- a) assess the likelihood and effects of GNSS vulnerabilities in their airspace and utilize, as necessary, the mitigation methods as outlined in the guidelines contained in Appendix A to the report on Agenda Item 6;
- b) provide effective spectrum management and protection of GNSS frequencies to reduce the possibility of unintentional interference;

- c) take full advantage of on-board mitigation techniques, particularly inertial navigation;
- d) where determined that terrestrial navigation aids need to be retained as part of an evolutionary transition to GNSS, give priority to retention of DME in support of INS/DME or DME/DME RNAV for en-route and terminal operations, and of ILS or MLS in support of precision approach operations at selected runways; and
- e) take full advantage of the future contribution of new GNSS signals and constellations in the reduction of GNSS failures and vulnerabilities.

6.2.3.9 It was suggested that the recommended guidelines should be considered for inclusion in the GNSS Manual which, in its draft form, was made available to the meeting for information. The suggestion was noted by the Secretariat.

6.2.3.10 During the review of GNSS vulnerabilities, a number of concerns was raised in regard to the ionospheric effects in equatorial regions. Several States reported that they had established data collection programmes and proposed that ICAO assess the results of such studies and provide appropriated guidance to States. The meeting encouraged continuation of these efforts and exchange of data between States and regions, noting that such data exchange was already taking place in some international expert groups, e.g. the SBAS Interoperability Working Group (IWG). The meeting therefore developed the following recommendation:

Recommendation 6/3 — Assessment of atmospheric effects on SBAS performance in equatorial regions

That ICAO, in order to aid the work on mitigation of ionospheric effects on SBAS performance in equatorial regions, assess the results of data collection being carried out in States and develop appropriated guidance material.

6.2.3.11 The meeting also reviewed a proposal to consider the need for standardization of an automated means to report GNSS outages and determine the effects of an outage on GNSS operations. In this regard, the meeting noted information on the example software posted on the ICAO Web site to demonstrate a prediction tool which can support flight planning and NOTAM generation. Having appreciated this initiative, the meeting was of the opinion that a uniform application of such tools was essential and developed the following recommendation:

Recommendation 6/4 — Automated means for reporting and assessing the effects of outages on GNSS operations

That ICAO consider standardization of an automated means of monitoring and reporting scheduled and unscheduled GNSS outages and assessing their effects on GNSS operations and develop, as necessary, the requisite provisions.

6.2.4 RNP and RNAV issues

6.2.4.1 The meeting was informed of a number of open issues surrounding different definitions and concepts related to required navigation performance (RNP) and area navigation (RNAV). Further concerns were raised that, despite efforts to develop and implement a cost-effective global definition of RNP, it was unlikely that the harmonization of the concept and requirements in this area could be achieved in the near future. The rationale for these concerns included dependance of most RNAV systems upon ground infrastructure which was location dependent, the potential for a variety of required RNAV functionalities associated with the same RNP types in various ATC environments, and avionics versatility driven by cost effectiveness considerations or resulting from evolutionary development of RNAV/FMS systems. The meeting recognized the complexity of the issues involved and shared these concerns.

6.2.4.2 In this regard, one State informed the meeting that it was currently implementing performance-based RNAV procedures and airspace restructuring to take advantage of aircraft navigation capabilities to fly more accurate and predictable flight paths through its airspace. Performance-based RNAV would result in increased levels of navigation accuracy and flight path predictability, leading to improved efficiency and capacity. This State was also implementing required navigation performance (RNP) approach procedures and developing a strategy for the introduction of RNP for other phases of flight. In the context of the above, it also expressed concern about a state of affairs with RNP and RNAV concepts.

6.2.4.3 The meeting was informed that on 10 June 2003, during consideration of the report of the fourth meeting of the Global Navigation Satellite System Panel (GNSSP/4), the Air Navigation Commission had agreed that, as proposed in GNSSP/4 Recommendation 1/1, action should be taken to establish a focal point for the resolution of the issues identified. It had been noted during consideration of this matter that there was an urgent need to address these issues in order to ensure a harmonized approach to the further development of RNP and RNAV. Accordingly, a new air navigation study group named as the Required Navigation Performance Study Group (RNPSG) had been established. Several States and international organizations attending the meeting expressed their commitment to support the work of RNPSG.

6.2.4.4 In supporting the above action, the meeting also noted that air navigation service providers were making investments in their navigation infrastructure as they implement new RNAV and RNP procedures. As these procedures were developed and used, States were modifying separation standards to account for enhanced aircraft navigation capability, and redesigning airspace for best use of these new procedures. The schedule for implementation of new requirements should be coordinated to align with infrastructure investments and to allow operators sufficient time to equip with the needed capabilities. In this

connection, the meeting stressed an urgent need for global harmonization of performance-based navigation concepts and requirements and the leading role of ICAO in this harmonization activities. It was suggested that by the end of 2004, a framework should be developed for the resolution of issues identified by GNSSP/4, particularly RNP definitions and terminology, and other issues relating to the implementation of performance-based navigation operations. By the end of 2005, the operations approval criteria, the obstacle clearance criteria, and the separation criteria for performance-based navigation operations should be defined or updated, as appropriate. Accordingly, the meeting developed the following recommendation:

Recommendation 6/5 — Early resolution of issues arising from implementation of RNAV and RNP

That ICAO as a matter of urgency address and progress the issues associated with the introduction of RNP and RNAV.

**6.2.5 Advanced GNSS capabilities
and new technology alternatives**

6.2.5.1 The meeting was presented with information on the status of initial GNSS implementation in one State. It was stressed that the key motivation for the introduction of satellite navigation services was the ability of new services to solve airspace issues and increase the availability of instrumental flight procedures. A number of distinctive features of GNSS was elaborated as enablers of improvements in terms of accessibility, flexibility in terminal area operations and RNAV coverage, particularly in mountainous (obstacle rich) environments or under other constraints (e.g. noise abatement requirements). Accordingly, the meeting was presented with a proposal that ICAO needs to focus on updating and development of Standards and procedures providing for realization of GNSS operational and safety benefits including those associated with advanced system capabilities.

6.2.5.2 The meeting was cautioned that the current state of development of ICAO technical Standards was still insufficiently advanced to support those capabilities in the near term. Specifically, the meeting was informed that the development of the relevant GNSS performance requirements for such capabilities currently underway within the Navigation Systems Panel (NSP) was expected to be completed in 2007. Hence, development of the corresponding GNSS SARPs could only be completed after 2007 with procedures and criteria to follow. Concerns were also expressed that some of the additional developments that were proposed might entail substantial indirect costs to the user community. However, the meeting noted that not all the proposed developments were necessarily of a challenging technical nature and that some States were already engaged in studies of proposed capabilities. The meeting therefore developed the following recommendations:

Recommendation 6/6 — Advanced GNSS procedure design

That ICAO develop RNAV procedures supported by GNSS for both fixed and rotary wing aircraft, enabling lower operating minimas in obstacle rich or otherwise constraint environments.

Recommendation 6/7 — Curved RNAV procedures

That ICAO develop RNAV procedures supported by GNSS for fixed wing aircraft, providing high track and velocity keeping accuracy to maintain separation through curves and enable flexible approach line-ups.

6.2.5.3 In follow-up to the above discussion, the meeting's attention was drawn to the significant inertial capability that existed in the world's aircraft and to benefits that can be derived from integrated GNSS/INS applications. It was recalled that such applications were recognized as a valuable mitigation in meeting deliberations of GNSS vulnerabilities. It was also noted that many aircraft used inertial data to complement performance of ILS in precision approach and landing operations, and, similarly, the integration of GNSS with INS can enhance navigation performance in terms of accuracy, integrity, availability and continuity.

6.2.5.4 The meeting noted, however, that realization of full benefits of GNSS/INS integration was constrained by the lack of standardization of system capabilities and its characteristics, particularly coasting times that constitute an essential factor of risk assessment and mitigation strategies. The meeting, therefore, developed the following recommendation:

Recommendation 6/8 — GNSS/INS integration

That ICAO develop provisions for the integration of GNSS/INS in order to reduce the vulnerability of GNSS to RF interference and aid the development of advanced GBAS capabilities.

6.2.5.5 The meeting reviewed the feasibility assessment of GNSS-based Category II/III approach and landing and aerodrome surface operations. It was recalled that the current Standards and Recommended Practices (SARPs) for GBAS provide augmentation to the core satellite constellations of GLONASS and GPS and support Category I precision approach. Galileo would be added to the core satellite constellations and its local component would be standardized as an amendment to the GBAS SARPs at a later date. It was also noted that a goal of GBAS development in support of Category II/III operations was to enable the evolution of the basic Category I architecture to Category III minimizing changes to the basic system and ensuring backwards compatibility with existing Category I avionics.

6.2.5.6 The assessment results had indicated that Category II/III capability would be achieved in the 2010-2015 time frame depending on the GBAS architecture and performance requirements. The final outcome of the ongoing development of the performance requirements and standards would also influence the complexity of the future GBAS architecture supporting Category II/III approach and landing operations and when it would be generally available. Expressing concerns over possible complexity of the future GBAS architecture, the meeting however supported a conclusion that the benefits of having a single system which can provide guidance in all phases of flight justified continued work on the resolution of technical and operational issues involved.

6.2.5.7 The meeting was also made aware of current studies in States in support of advanced surface movement guidance and control systems (A-SMGCS) and the work in the Navigation Systems Panel which was focussing on the application of GNSS as a position sensor for A-SMGCS.

6.2.6 Pre-operational experiences

6.2.6.1 The meeting received information from a number of States and regional organizations regarding trials being carried out in the Caribbean, South American and African Regions at the regional and national levels to collect data for the definition of the GNSS architectures in these regions. A three-stage GNSS implementation strategy in the AFI Region and the initial results of the EGNOS test bed trials conducted in the region were reported to the meeting. The meeting was also presented with the information on trials involving WAAS and EGNOS test beds in the CAR/SAM States.

6.2.6.2 The lessons learnt and proposals stemming from the experiences gained were reviewed by the meeting. These concerned a broad range of issues, including human resources, regional training capabilities, the need for integration of technical cooperation projects and financing aspects. The meeting was made aware of ICAO activities and groups addressing these issues. The meeting also noted with appreciation the support States involved in the development of WAAS and EGNOS were providing within the framework of the SBAS test bed trials. To encourage the continuation of these activities, the meeting developed the following recommendation:

Recommendation 6/9 — Support of and participation in SBAS pre-operational implementation activities

That:

- a) States that develop and introduce satellite-based augmentation systems and other SBAS service providers commence or continue to provide their technical and financial support and participation in the activities leading to the extension of their SBAS service areas into neighbouring States and Regions; and
- b) States participating in SBAS implementation activities coordinate with other participating States to optimize their effort, minimize duplication of service and facilitate participation of service providers.

6.2.7 Other related issues

6.2.7.1 Concerning the issue of legal and institutional aspects of GNSS referred to in AN-Conf/11-WPs/143, 153 and 160, the meeting agreed that neither the scope nor the agenda presented a suitable opportunity for discussions on those topics. Therefore, the meeting, assisted by the President of the Council, Dr. A. Kotaite and the Director of the Legal Bureau, agreed to note the information and views contained in the above referenced papers and agreed that they should be referred to the ICAO Council for urgent consideration and action as deemed appropriate by that ICAO body.

6.2.7.2 Concerning the issue of economics aspects of GNSS referred to in AN-Conf/11-WP/107, the meeting agreed that neither the scope nor the agenda presented a suitable opportunity for discussions on this topic. After receiving an update report of Air Navigation Services Economics Panel (ANSEP) work by the secretary of the panel, the meeting noted some principles and assumptions endorsed by ANSEP to be applied for cost allocation between civil aviation and other users, in particular that basic GNSS services should be provided free of direct users charges and that any cost allocation of GNSS services should take place at the regional level. The meeting concluded that the information and the views contained in the above reference paper should be brought to the attention of ANSEP.

**6.3 AMENDMENTS ON AERONAUTICAL NAVIGATION
SUBJECTS IN RELEVANT ICAO DOCUMENTS
INCLUDING THE *GLOBAL AIR NAVIGATION PLAN
FOR CNS/ATM SYSTEMS (DOC 9750)*, ANNEX 10 —
*AERONAUTICAL TELECOMMUNICATIONS AND
OTHER DOCUMENTS AS NECESSARY***

**6.3.1 Proposed updates to the ICAO Strategy for the
introduction and application of non-visual aids to approach
and landing
in Annex 10, Volume I**

6.3.1.1 The meeting was presented with updates, developed by the Global Navigation Satellite System Panel (GNSSP) at the request of the Air Navigation Commission (ANC), to the ICAO Strategy for the introduction and application on non-visual aids to approach and landing in Annex 10, Volume I, Attachment B. The meeting was advised that proposed amendments to the strategy took account of developments in aeronautical navigation since the strategy was approved by the COM/OPS Divisional Meeting in 1995. In particular, the progress was contemplated in the development of GNSS and introduction of GNSS-based operations.

6.3.1.2 In addressing proposed amendments the meeting agreed that the general objectives of the strategy were still valid and not affected by any developments since 1995. Accordingly, the meeting extended the applicability for the updated strategy until 2020.

6.3.1.3 The meeting was reminded that the current strategy had introduced a notion of generic criteria for approach, landing and departure operations which was intended to facilitate the application of emerging technologies for precision approach and landing operations. The development of the Standards and Recommended Practices (SARPs) for GNSS-based precision approach operations had shown that the required navigation performance (RNP) concept did not replace the need for detailed system-specific SARPs. Such SARPs for GNSS to support Category I precision approach were developed after the concept had been introduced, and additional standards were under development for Category II/III. Having noted that with the adoption of GNSS SARPs three standard aids were established, providing for the whole variety of precision approach and landing operations, the meeting agreed that no new precision approach and landing systems need to be standardized. References to the generic RNP criteria for precision approach and landing were no longer deemed necessary and therefore deleted in the proposed amendment to the strategy.

6.3.1.4 The meeting reviewed the strategy based on the latest information available and its previous deliberations. The most significant changes concerned the following areas:

- a) there had been some significant advances in the implementation of Category III MLS;
- b) approach with vertical guidance (APV) with satellite-based augmentation reached operational capability;
- c) GNSS with ground-based augmentation capable of supporting Category I operations did not progress as projected and was expected to become operational by 2006. Development of performance requirements and SARPs for GNSS ground-based augmentation system (GBAS) to support Category II and III operations was in progress. However, it was not possible at the time to give an accurate forecast when an operational capability would be available. Thus, availability time frames were changed from 2005 - 2015 to 2010 - 2015;
- d) there had been some significant developments related to the multi-mode receiver (MMR). Multi-mode receiver industry Standards had been developed and MMRs had been fielded with ILS and basic GNSS functions. Other MMR functions such as MLS and GBAS were under development and expected to be available in the near future;
- e) as MMR was only one specific implementation of airborne landing capability, a more generic notion of multi-modal capability was introduced;
- f) as transition to GNSS as a global system for all phases of flight was recognized to be a long-term objective. Thus, the frequency bands allocated to ILS, MLS and GNSS needed to be protected indefinitely. A statement to this effect was included in the strategy; and
- g) Standards and criteria for approach and landing with vertical guidance (APV) were available or under development. APV procedures based on various technologies offered operational benefits and enhanced safety compared with non-precision approaches, particularly in regard to prevention of CFIT incidents/accidents. Thus, the strategy was expanded to include general information to this effect.

6.3.1.5 In reviewing proposed amendments to the strategy, the meeting was presented with and noted the IATA position on non-visual aids for Category II/III approach and landing. Taking IATA's views into account, the meeting agreed to update the strategy as shown in Appendix B to the report on this agenda item. The meeting therefore developed the following recommendation:

RSPP	Recommendation 6/10 — Amendment to Annex 10, Volume I, Attachment B — Updating the strategy for introduction and application of non-visual aids to approach and landing That Attachment B to Annex 10, Volume I be amended as shown in Appendix B to the report on Agenda Item 6.
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6.3.2 Amendments to the Global Plan

6.3.2.1 The meeting reviewed a proposal developed by the GNSSP to amend the navigation parts of the *Global Air Navigation Plan for CNS/ATM Systems* (Doc 9750) including, inter alia, updates to the document to reflect recent developments in the global navigation satellite system (GNSS).

6.3.2.2 The proposed amendments were based on the following key considerations:

- a) a vision of GNSS is evolving away from the concepts of supplementary, primary or sole means of navigation (using a single system) to the concept of multiple sensors to be used for area navigation and approach, landing and departure operations, where GNSS elements are regarded as individual sensors;
- b) the goal of transition to GNSS, which removes the requirement for conventional ground-based navigation aids, is maintained for the GNSS-based navigation and future ATM environments where this goal can be safely and cost-effectively achieved;
- c) the need for some or all conventional ground-based navigation aids during the transition is maintained until such time when the requirements for safe and cost-effective operations using GNSS are met; and
- d) the need to retain conventional ground-based navigation aids during the transition does not imply a requirement to add ground-based NAVAIDs in less developed regions when introducing GNSS-based operations unless it is demonstrated that the safe implementation of particular operations demand such additional NAVAIDs.

6.3.2.3 The meeting developed additional amendments that were included in the proposal to take account of its earlier discussions concerning:

- a) vulnerability of GNSS to interference and the need for means of mitigation;
- b) enhanced role of DME and INS/IRS in the provision of navigation service; and
- c) importance of RNAV and RNP in the realization of GNSS benefits.

6.3.2.4 The meeting also considered a proposal to amend the time lines for implementation of CNS/ATM systems for the AFI Region which were contained in Part II of the Global Plan. It was stated that the originally expected pace of implementation has not been achieved, particularly in the AFI Region due to a number of factors such as delays in the availability and installation of appropriate avionics and lack of funding.

6.3.2.5 Arising from the above, the AFI States extended their time frame for CNS/ATM systems implementation up to 2015. Nevertheless, the ultimate objective of the region was a navigation system based on satellite navigation for all phases of flight. As far as augmentation was concerned, any deployment was to be in line with the regional policy as defined and approved by AFI Planning and Implementation Regional Group (APIRG). It was noted that strategy had detailed an evolutionary path from existing constellations through a minimal SBAS providing over the whole AFI Region a non-precision approach capability with vertical guidance at the 20 m vertical accuracy and vertical alert limit of 50 m (APV-I).

6.3.2.6 The meeting took note of the information provided on the implementation objectives and plans. Concerning the proposed amendments to the implementation time lines, it was noted that similar changes may be proposed by other ICAO regions and that all such changes should be consolidated and reflected in the next edition of the document.

6.3.2.7 In concluding its consideration of the subject, the meeting updated the Global Plan as shown in Appendix C to this agenda item and developed the following recommendation:

**Recommendation 6/11 — Amendment to the Global Plan —
Navigation**

That:

- a) the *Global Air Navigation Plan for CNS/ATM Systems* (Doc 9750) be amended as shown in Appendix C to the report on Agenda Item 6; and
- b) updated CNS/ATM systems implementation time lines contained in Part II of the Global Plan be reviewed by the Regional Implementation Group and consolidated for incorporation in the next edition of the Global Plan.

**6.4 DIRECTIONS FOR FUTURE DEVELOPMENT OF
AERONAUTICAL NAVIGATION SERVICES**

6.4.1 Concept of using combinations of independent satellite navigation systems and their augmentations

6.4.1.1 The meeting was presented with the results of study carried out by the Global Navigation Satellite System Panel (GNSS) at request by the ICAO Air Navigation Commission. The study indicated that the increasing number of GNSS signals and constellations would offer significant benefits to civil aviation in terms of improved robustness and performance, simplification of GNSS ground architecture and alleviation of institutional concerns. The study also cautioned that the introduction of these new elements would raise some technical, economical and institutional issues.

6.4.1.2 The meeting recalled that information presented on GNSS development (Section 6.1 of this report refers) had indicated that GPS would be enhanced by providing additional signals and modernized satellites. It was also reported that modernized GLONASS satellites with improved characteristics would be added to the constellation. Further, a new constellation called Galileo which would provide three signals and a worldwide integrity function was being developed by Europe. It was understood that for any new signal and/or constellation, an additional time period of one to two years would probably be needed for the purpose of validation and certification by civil aviation authorities before new GNSS elements could be used for safety-of-life applications. This implied that the operational use of new signals and combined constellations service could start in the 2010 — 2015 time-frame.

6.4.1.3 The meeting recognized that the implementation of a multiplicity of different possible combinations of elements would result in overall system complexity and negative economic impact particularly on the user side and concluded that this can be avoided by the thorough assessment and selection of the most promising combinations for general implementation. Accordingly, the meeting developed the following recommendation:

Recommendation 6/12 — Development of guidance material on applications of new GNSS elements and their combinations

That ICAO, in developing standards for new GNSS elements and signals, address the issues associated with the use of multiple signals and their combinations, and develop guidance on the most promising combinations of GNSS elements.

6.4.1.4 The meeting was apprised that current GNSS avionics automatically select which satellites and augmentation elements to use. It was noted in this regard that State regulations could require or prohibit the use of certain future GNSS elements or their combinations in some airspaces. The meeting agreed that such a situation could result in significant costs for users in terms of additional cockpit controls and procedures, crew training and maintenance support or become a safety issue due to human factors considerations. It also agreed that these potential repercussions require ICAO to encourage States, in their planning for implementation of GNSS services, to avoid limitations on the use of specific GNSS elements for institutional reasons. The meeting therefore developed the following recommendation:

Recommendation 6/13 — Potential constraints on using multiple GNSS signals

That States, in their planning for implementation of GNSS services, take full advantage of future benefits accrued from using independent core satellite constellations, other GNSS elements and their combinations, and avoid limitations on the use of specific system elements.

6.4.1.5 Having completed the review of the study results documented for the meeting's consideration, the meeting concluded that the document represented a useful overview of benefits from, and issues associated with the introduction of new elements of GNSS. Accordingly, the meeting agreed this overview to be included in Appendix D to the report on this agenda item.

6.4.2 GNSS services in the 960 - 1 215 MHz band

6.4.2.1 The meeting recalled that in its discussion on mitigation of GNSS vulnerabilities and benefits offered by the future development of GNSS, the introduction and use of additional "second civil" frequencies was emphasized on a number of occasions. In this regard, it was noted that the United States had decided to implement a second GPS civil frequency, known as L5, in the band 1 164.45 - 1 188.45 MHz. In parallel with this decision, Galileo signals would also utilize spectrum in the 1 164 - 1 215 MHz frequency range. The Russian Federation also reported plans to introduce an additional signal(s) in this frequency range as a part of the GLONASS modernization programme. These signals would be introduced in accordance with the ITU allocation of the 960 - 1 215 MHz band to the radionavigation satellite service (RNSS) on the conditions specified in ITU Radio Regulations, Footnote 5.328A (MOD-03) and Resolution 609 (WRC-03).

6.4.2.2 The meeting was reminded that the band 960 - 1 215 MHz, which continues to be allocated to the aeronautical radionavigation service (ARNS), was being heavily used by ICAO standardized distance measuring equipment (DME).

6.4.2.3 The meeting was made aware of a potential for interference to GNSS receivers in the 1 164.45 - 1 188.45 MHz band and to a lesser extent (due to the frequencies being used for special national allocations) in the 1 197.14 - 1 215 MHz band. The level and hence impact of interference was related to how many pulses transmitted by DME ground transponders in these portions of the band can interfere with the aircraft GNSS antenna (the airborne interrogators do not operate at these frequencies).

6.4.2.4 The meeting agreed that, in cases where the shared use of DME and GNSS in the same frequency band may lead to unacceptable interference, ways of mitigating the interference, while maintaining the aeronautical radionavigation services, need to be considered. This could be achieved by:

- a) modifying future DME installations to reduce the quiescent squitter rate as practicable (Annex 10, Volume I, Chapter 3, paragraph 3.5.4.1.5.6 refers);
- b) by making greater use of Y-channel DMEs; and

- c) by re-assigning the current frequencies where practicable.

6.4.2.5 The meeting therefore developed the following recommendation:

Recommendation 6/14 — GNSS services in the 960 - 1 215 MHz band

That,

- a) States be encouraged to take into account the need to minimize potential interference to GNSS services in their planning of the deployment of DMEs; and
- b) an appropriate ICAO body be tasked to review the issues listed in paragraph 6.4.2.4 of the report on Agenda Item 6.

6.4.3 Review of Annex 10 SARPs for ground-based radio navigation aids in the light of present and planned GNSS services

6.4.3.1 The meeting was presented with the results of the preliminary review of Standards and Recommended Practices (SARPs) in Annex 10, Volume I undertaken by the GNSS Panel at the request of the Air Navigation Commission (ANC) in order to assess the need for updates of the document in the light of present and planned GNSS services. The objective of the review was to identify the areas where additional work should be initiated to investigate the impact of potential changes to the Standards and develop draft amendments to the Annex if necessary.

6.4.3.2 The meeting noted that future implementation of GNSS capable of providing global navigation coverage and area navigation (RNAV) capabilities in support of all phases of flight would overlay a number of capabilities and functions delivered by the existing radio navigation aids defined in Annex 10. The identified candidate parts with the potential to require modifications were generally those where SARPs may become redundant through the introduction of GNSS or alternatively where the Standards in their present form may prove problematic in the transition to satellite navigation.

6.4.3.3 The meeting also noted that, although these candidate parts were identified with the focus on GNSS-related aspects, a number of the potential updates were resulting from the increasing application of ground-based navigation aids in support of RNAV operations.

6.4.3.4 The meeting agreed that further work is required to investigate the feasibility of amending SARPs and guidance material in Annex 10, Volume I taking into account the potential for reduction of redundant navigation functionalities and protection considerations, and to develop draft amendments to the Annex as necessary. The issues to be addressed included:

- a) general review of protection dates;

- b) changes to DME specifications, taking account of the increasing use of this system in support of terminal RNAV operations and the use of DME/DME RNAV as a back up option to GNSS;
- c) requirements for DME/P;
- d) requirements for MLS/RNAV and updates of MLS specifications; and
- e) updates of guidance material on DME, ILS and VOR service volumes and frequency planning.

6.4.3.5 Based on the above, the conference developed the following recommendation:

Recommendation 6/15 — Updating of SARPs for radio navigation aids in Annex 10, Volume I

That ICAO undertake a review of SARPs and guidance material in Annex 10, Volume I in the areas identified in paragraph 6.4.3.4 of the report on Agenda Item 6.

6.4.3.6 Noting the scope of Volume I of Annex 10, the meeting acknowledged close correlation and connection between Recommendations 6/14 and 6/15.

6.4.4 Enhanced data integrity for RNAV and GNSS-based operations

6.4.4.1 The meeting was made aware that, during the first GNSS procedure and RNAV operation implementation trials, deficiencies revealed in the quality of the aeronautical data in airborne systems had included errors and/or discrepancies between the data encoded in the computer-based navigation system and the data published in the Aeronautical Information Publication (AIP). It was noted that the main sources of errors were as a result of non-compliance with the data quality provisions in Annex 15 during the origination phase, and the alteration of data during the various processes of the aeronautical data chain.

6.4.4.2 It was further noted that, although ICAO had developed SARPs that govern various aspects of processing electronic aeronautical information, it could not prevent flight critical data from being processed manually. Although several initiatives had been launched to address the problem of data integrity, especially in the context of RNAV implementation, there were no coordinated system or applicable standards to make sure that the required levels of data integrity are met all the way through the aeronautical data chain, from origination to end-use. The meeting was also informed of some discrepancies between the industry and the ICAO data quality requirements for accuracy, integrity and resolution.

6.4.4.3 In the discussion of issues raised, safety aspects of aeronautical data quality, particularly the integrity of data for RNAV and GNSS-based operations, were emphasized by many States and international organizations. In this regard, the meeting stressed an urgent need for ICAO to develop guidance material

covering the acquisition of data from various sources, processing and assessment of the overall quality. It was suggested the material should also address detecting the data corruption events (alteration of the data by a given organisation without acknowledgement to the other involved organisations) in the aeronautical data chain. It was also suggested that the task of harmonization of Annex 15 data quality requirements and corresponding industry standards be endeavoured without delay.

6.4.4.4 In follow up to suggested actions, the meeting was made aware of work under way in ICAO to address the shortcomings tabled before the meeting. In particular, the meeting noted the progress of a task (AIS-9401) of the *Technical Work Programme (TWP) of the Organization in the Air Navigation Field* which included, among other things, the development of guidance material for the application by the aeronautical information services of the ISO 9000 standard series that would provide for the quality assurance of aeronautical information. The meeting was advised that this work was approaching the final stage and the Quality Management System Manual for AIS/MAP Services was to be completed by the end of 2003. The meeting also noted that in accordance with a recommendation of the Global Navigation Satellite System Panel (GNSSP/4 Recommendation 3/4), the Navigation Systems Panel (NSP) had been requested to develop specific proposals towards harmonization of ICAO and industry standards for aeronautical data used in support of GNSS-based operations.

6.4.4.5 Having noted the above, the meeting developed the following recommendation:

**Recommendation 6/16 — Completion of guidance material on
application of data quality SARPs in
Annex 15**

That ICAO give high priority to the completion of guidance material for the data quality assurance including the data processing from origination to end-use.

6.4.5 Proposals for the future development of GNSS navigation services in the regions

6.4.5.1 In conclusion of its deliberations on aeronautical navigation issues, the meeting reviewed information on the Asia/Pacific Regional strategies for navigation services and proposals for the future regional development of GNSS navigation services.

6.4.5.2 The meeting noted the strategy for the provision of precision approach and landing guidance systems and the strategy for the implementation of GNSS navigation capability in the Asia/Pacific Region that had been adopted by the Fourteenth Meeting of the ASIA/PAC Air Navigation Planning and Implementation Regional Group (APANPIRG/14).

6.4.5.3 In regard to information and proposals developed and presented pursuant to Conclusion 11/54 of the Eleventh Meeting of the CAR/SAM Regional Planning and Implementation Group (GREPECAS/11), the meeting appreciated the progress in the trials and planning for GNSS navigation services. It agreed that the resulting experiences and challenges may be of general interest for other regions. These included activities

in the development of regional satellite navigation service that can be progressed with small investments due to regionally coordinated efforts and committed participation of States. Human resource training and financing issues were noted as major challenges in implementing complex technology systems such as GNSS.

6.4.5.4 The meeting was informed that ICAO was using of three different mechanisms to provide assistance to States for the implementation of CNS/ATM systems on continuous basis. These included Special Implementation Projects, Technical Cooperation Projects and International Financial Facility for Aviation Safety. In addition, ICAO was undertaking periodical technical visits to States, developing regional guidance material and conducting regional workshops.

6.4.5.5 In concluding its discussions on aeronautical navigation issues, the meeting once again, in line with its Recommendation 6/1, emphasized the need for ICAO, States, airspace users and other parties concerned to continue work towards the safe and efficient global navigation system for all phases of flight.

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