Cir 321
AN/183

Guidelines for the implementation of GNSS longitudinal separation minima

**Approved by the Secretary General
and published under his authority**

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ABBREVIATIONS

AIC	Aeronautical information circular
AIP	Aeronautical information publication
AIRAC	Aeronautical information regulation and control
AIS	Aeronautical information services
ANSP	Air navigation service provider
ATC	Air traffic control
ATS	Air traffic services
CAR/SAM	Caribbean and South American
DCPC	Direct controller-pilot communications
DME	Distance measuring equipment
FAA	Federal Aviation Administration
FD	Fault detection
FDE	Fault detection and exclusion
FMS	Flight management system
GLONASS	GLObal NAvigation Satellite System
GNSS	Global navigation satellite system
GPS	Global positioning system
ICAO	International Civil Aviation Organization
IFR	Instrument flight rules
m	metre
MSG	Mathematicians sub-group
NAT	North Atlantic
NAVAIDs	Navigation aids
NDB	Non-directional beacon
NM	Nautical mile
PANS-ATM	Procedures for air navigation services – air traffic management
PBN	Performance-based navigation
RAIM	Receiver autonomous integrity monitoring
RNAV	Area navigation
SASP	Separation and Airspace Safety Panel
SASP/WG/WHL	SASP Working Group of the Whole
SBAS	Satellite-based augmentation system
TAS	True airspeed
TSO	Technical standard order
VHF	Very high frequency
VOR	Very high frequency omnidirectional range
WGS-84	World Geodetic System – 1984
WP	Working paper

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Chapter 1

INTRODUCTION

PURPOSE

1.1   The purpose of this circular is to provide guidance for applying the global navigation satellite system/distance measuring equipment (GNSS/DME) separation minima. It is aimed at a worldwide audience within the civil aviation authorities responsible for implementing these and other separation minima.

1.2   As a result of the large number of aircraft equipped with instrument flight rules (IFR)-certified GNSS equipment for navigation and its potential use for separation in the procedural environment, the Separation and Airspace Safety Panel (SASP) developed the separation minima detailed in this circular for interim use in the period of transition to a widespread implementation of performance-based navigation (PBN). These separation minima are intended to exploit the capabilities and precision of GNSS equipment that, as a minimum, meet the requirements of FAA TSO C129a or better.

GENERAL

1.3   In 1996, the International Civil Aviation Organization (ICAO) endorsed the development and use of GNSS as a primary source of future navigation for civil aviation. ICAO noted the increased flight safety, route flexibility and operational efficiencies that could be realized from the move to space-based navigation. Since then, air navigation service providers (ANSPs), airline operators and avionics/receiver manufacturers have engaged in an ambitious effort to develop GNSS, related augmentation systems, airborne receivers and ground infrastructure and to implement procedures, equip aircraft and train pilots in the use of satellite navigation.

1.4   GNSS provides significant improvements in relation to conventional radio navigation installations because of the global availability and accuracy of the GNSS signal. The potential for using GNSS for the application of separation was identified by SASP, and it has been working on developing GNSS-based separation minima since 2002. The first minima, for GNSS longitudinal separation, were published in November 2007, and the second will relate to GNSS lateral separation minima.

EXPLANATION OF TERMS

Accuracy. A measure of the difference between the true aircraft position and a measured/reported/estimated aircraft position. Accuracy may be defined as a bias (offset) and noise. The noise is usually characterized by a standard deviation and may have either a Gaussian or a different type of probability distribution. Accuracy may also be defined as a 95th percentile value.

Availability. The ability of a system to perform its required function at the initiation of the intended operation. It is quantified as the proportion of time the system is available to the time it had been planned for the system to be available. Periods of planned maintenance are discounted from the availability figures. Overall availability is composed of:

a)   the availability of functions affecting all aircraft (e.g. external positioning function, ground data acquisition function); and

b)   the availability of systems affecting only one aircraft (e.g. transponder function), expressed per flight hour.

Continuity. The probability that a system will perform its required function without unscheduled interruption, assuming that the system is available when the procedure is initiated. Overall, continuity is composed of:

a)   the continuity of functions affecting all aircraft (e.g. satellite function, ground data acquisition function), expressed in a number of disruptions per year; and

b)   the continuity of systems affecting only one aircraft (e.g. transponder function), expressed per flight hour.

Integrity. The level of trust that errors will be correctly detected. Integrity risk is the probability that an error in the information larger than a given threshold is undetected for longer than a time to alert.

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Chapter 2

GLOBAL NAVIGATION SATELLITE SYSTEM (GNSS)

INTRODUCTION

2.1   This chapter provides an overview of GNSS positioning in the context of using GNSS as a basis for separation minima in a procedural environment. The information is mainly based on that published in the ICAO *Global Navigation Satellite System (GNSS) Manual* (Doc 9849).

2.2   GNSS is global in scope and fundamentally different from traditional navigation aids (NAVAIDs). It has the potential to support all phases of flight, resulting in a seamless global navigation guidance system. GNSS provides accurate guidance in remote and oceanic areas where it is impractical, too costly or impossible to install traditional NAVAIDs. It also guarantees that all operations are based on a common navigation reference.

GNSS CORE CONSTELLATIONS AND POSITIONING

2.3   Currently there is one fully operational core satellite constellation: the global positioning system (GPS) provided by the United States of America. Other core constellations include the Russian system, GLONASS, which as of February 2009 consisted of 20 operational satellites, and the European Galileo system, which is currently under development. These systems will provide independent capabilities but could be used in combination with GPS in the future with specifically designed receivers to improve GNSS robustness.

2.4   Satellites in the core constellations broadcast a timing signal and a data message that includes their orbital parameters (ephemeris data). The GNSS receiver computes position, velocity vector, time and possibly other information, depending on the application. Measurements from a minimum of four satellites are required to establish three-dimensional position (longitude, latitude and height). Accuracy is dependent on the precision of the time measurements from the satellites and the relative geometry of the satellites used. Once the receiver knows an aircraft's position, it can provide guidance (navigation) between waypoints selected from a database in the receiver. Guidance to a pilot is typically provided through both traditional course deviation indicators and moving map displays. To meet the performance criteria for aviation, GNSS must be able to ensure integrity, accuracy, availability and continuity to specified levels.

GNSS ACCURACY

2.5   GNSS offers position measurements that are equal to or more accurate than distance measuring equipment (DME), very high frequency omnidirectional radio range (VOR) and non-directional radio beacons (NDB). The collision risk calculations done to establish the GNSS longitudinal separation referred to in this circular assumed the GNSS along-track accuracy to be ±0.124 NM, GNSS cross-track accuracy to be ±1 NM, DME fix tolerance to be ±0.25 NM plus 1.25 per cent of the distance to the antenna, VOR accuracy to be ±1 NM and ±5.2 degrees and NDB accuracy to be ±1 NM and ±6.9 degrees. All of them were assumed to be 95th percentile containment values.

2.6   In addition to superior accuracy, the GNSS receiver ensures integrity by providing alerts when a position with respect to the phase of flight cannot be guaranteed within a specific degree of certainty. These alert limits are:

Typical operation	*Horizontal alert limit*
En-route	3.7 km (2 NM)
Terminal	1.85 km (1 NM)
Approach	556 m (0.3 NM)

2.7   GNSS provides position information to the user in terms of the World Geodetic System (WGS-84) geodetic reference datum.

GNSS LONGIDUTINAL SEPARATION MINIMA

2.8   The following presents the GNSS longitudinal separation amendment which was incorporated into the *Procedures for Air Navigation — Air Traffic Management* (PANS-ATM):

5.4.2.3   LONGITUDINAL SEPARATION MINIMA
BASED ON DISTANCE USING DISTANCE MEASURING
EQUIPMENT (DME) AND/OR GNSS

Note.— Where the term "on track" is used in the provisions relating to the application of longitudinal separation minima using DME and/or GNSS, it means that the aircraft is flying either directly inbound to or directly outbound from the station/waypoint.

5.4.2.3.1   Separation shall be established by maintaining not less than specified distance(s) between aircraft positions as reported by reference to DME in conjunction with other appropriate navigation aids and/or GNSS. This type of separation shall be applied between two aircraft using DME, or two aircraft using GNSS, or one aircraft using DME and one aircraft using GNSS. Direct controller-pilot VHF voice communication shall be maintained while such separation is used.

Note.— For the purpose of applying GNSS-based separation minimum, a distance derived from an integrated navigation system incorporating GNSS input is regarded as equivalent to GNSS distance.

5.4.2.3.2   When applying these separation minima between any aircraft with area navigation capability, controllers shall specifically request GNSS-derived distance.

Note.— Reasons making a pilot unable to provide GNSS distance information may include inadequate on-board equipment, no GNSS input into an integrated navigation system, or a loss of GNSS integrity.

5.4.2.3.3   AIRCRAFT AT THE SAME CRUISING LEVEL

5.4.2.3.3.1   *Aircraft on the same track:*

a)   37 km (20 NM), provided:

   1)   each aircraft utilizes:

      i)   the same "on-track" DME station when both aircraft are utilizing DME; or

      ii)   an "on-track" DME station and a collocated waypoint when one aircraft is utilizing DME and the other is utilizing GNSS; or

iii) the same waypoint when both aircraft are utilizing GNSS; and

2) separation is checked by obtaining simultaneous DME and/or GNSS readings from the aircraft at frequent intervals to ensure that the minimum will not be infringed (see Figure 5-21);

b) 19 km (10 NM), provided:

1) the leading aircraft maintains a true airspeed of 37 km/h (20 kt) or more faster than the succeeding aircraft;

2) each aircraft utilizes:

i) the same "on-track" DME station when both aircraft are utilizing DME; or

ii) an "on-track" DME station and a collocated waypoint when one aircraft is utilizing DME and the other is utilizing GNSS; or

iii) the same waypoint when both aircraft are utilizing GNSS; and

3) separation is checked by obtaining simultaneous DME and/or GNSS readings from the aircraft at such intervals as are necessary to ensure that the minimum is established and will not be infringed (see Figure 5-22).

5.4.2.3.3.2 *Aircraft on crossing tracks.* The longitudinal separation prescribed in 5.4.2.3.3.1 shall also apply provided each aircraft reports distance from the DME station and/or collocated waypoint or same waypoint located at the crossing point of the tracks and that the relative angle between the tracks is less than 90 degrees (see Figures 5-23A and 5-23B).

5.4.2.3.4 *AIRCRAFT CLIMBING AND DESCENDING*

5.4.2.3.4.1 *Aircraft on the same track:* 19 km (10 NM) while vertical separation does not exist, provided:

a) each aircraft utilizes:

i) the same "on-track" DME station when both aircraft are utilizing DME; or

ii) an "on-track" DME station and a collocated waypoint when one aircraft is utilizing DME and the other is utilizing GNSS; or

iii) the same waypoint when both aircraft are utilizing GNSS; and

b) one aircraft maintains a level while vertical separation does not exist; and

c) separation is established by obtaining simultaneous DME and/or GNSS readings from the aircraft (see Figures 5-24A and 5-24B).

Note.— To facilitate application of the procedure where a considerable change of level is involved, a descending aircraft may be cleared to some convenient level above the lower aircraft, or a climbing aircraft to some convenient level below the higher aircraft, to permit a further check on the separation that will be obtained while vertical separation does not exist.

5.4.2.3.4.2   *Aircraft on reciprocal tracks.* Aircraft utilizing on-track DME and/or collocated waypoint or same waypoint may be cleared to climb or descend through the levels occupied by other aircraft utilizing on-track DME and/or collocated waypoint or same waypoint, provided that it has been positively established that the aircraft have passed each other and are at least 10 NM apart, or such other value as prescribed by the appropriate ATS authority.

**Figure 5-21.   37 km (20 NM) DME and/or GNSS-based separation between aircraft
on same track and same level (see 5.4.2.3.3.1 a))**

**Figure 5-22.   19 km (10 NM) DME and/or GNSS-based separation between aircraft
on same track and same level (see 5.4.2.3.3.1 b))**

**Figure 5-23A.   37 km (20 NM) DME and/or GNSS-based separation between
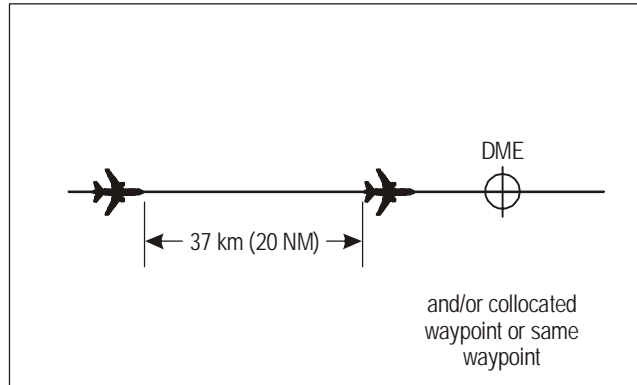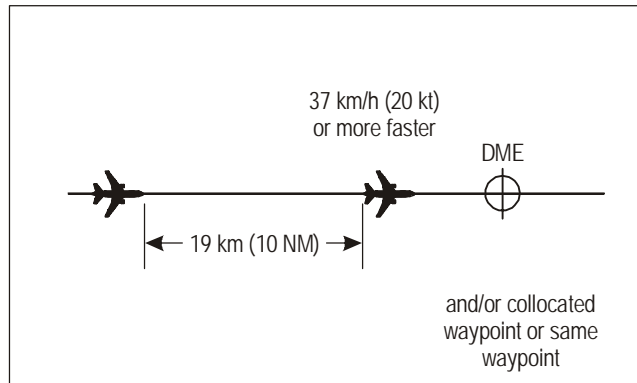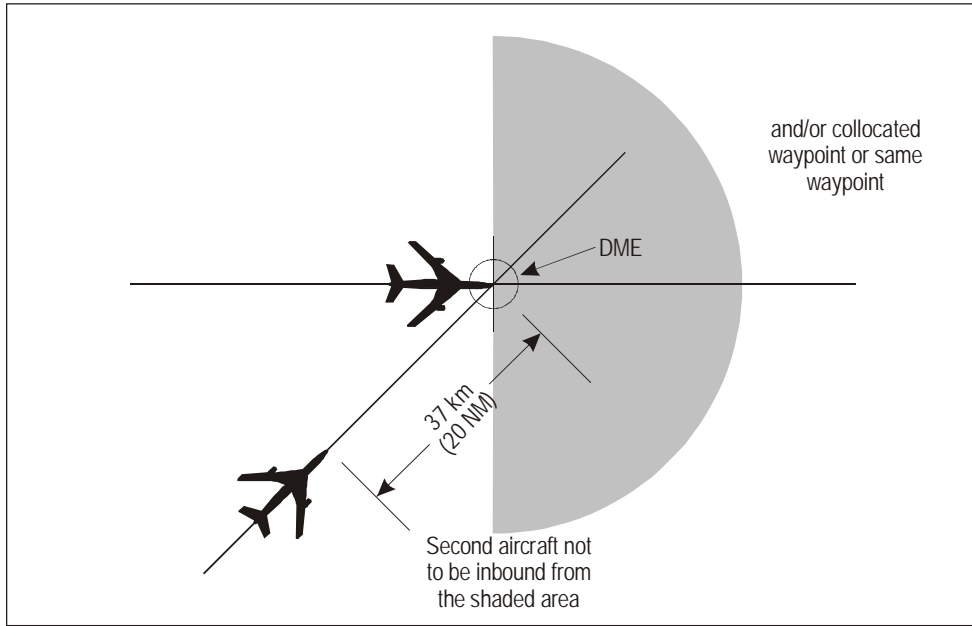aircraft on crossing tracks and same level (see 5.4.2.3.3.2)**
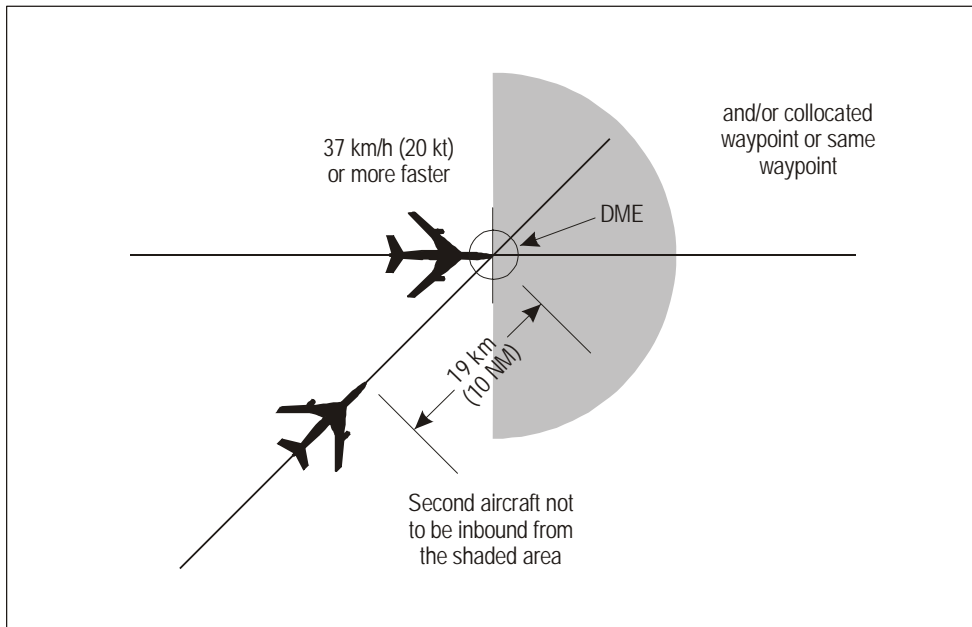
**Figure 5-23B.   19 km (10 NM) DME and/or GNSS-based separation between
aircraft on crossing tracks and same level (see 5.4.2.3.3.2)**
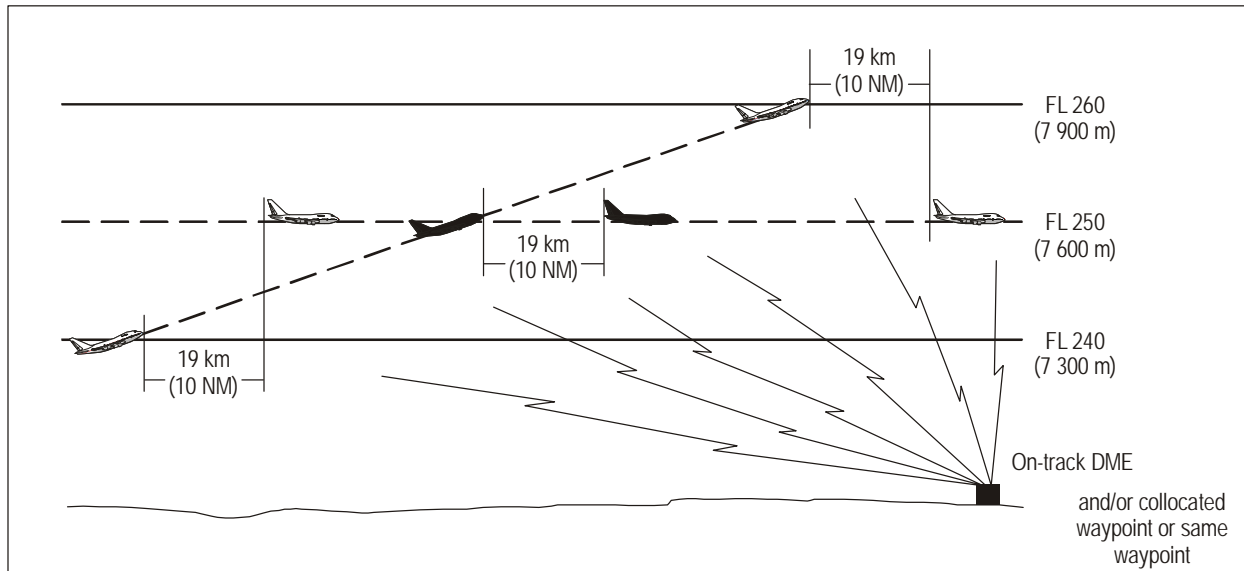
**Figure 5-24A.   19 km (10 NM) DME and/or GNSS-based separation between
aircraft climbing and on same track (see 5.4.2.3.4.1 c))**
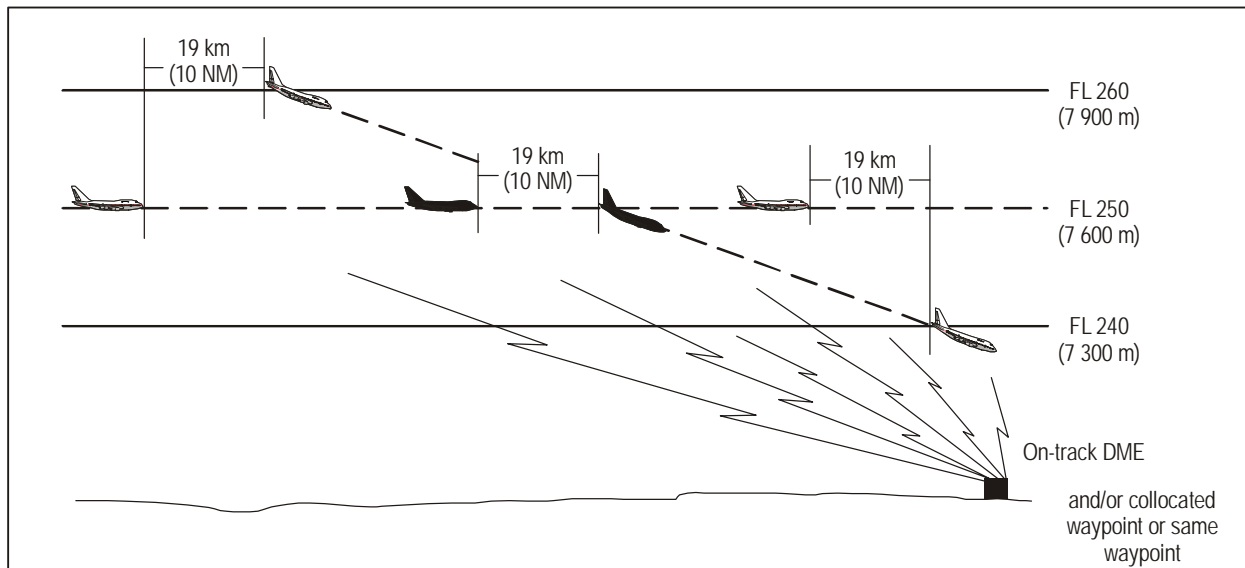
**Figure 5-24B.   19 km (10 NM) DME and/or GNSS-based separation between
aircraft descending and on same track (see 5.4.2.3.4.1 c))**

GNSS TERMINOLOGY

2.9   **Receiver autonomous integrity monitoring (RAIM).** RAIM provides integrity monitoring of GPS for aviation applications. In order for a GPS receiver to perform RAIM or fault detection (FD) functions, a minimum of five visible satellites with satisfactory geometry must be visible to it. The RAIM function performs consistency checks between position solutions obtained with various subsets of the visible satellites. The receiver provides an alert to the pilot if the consistency checks fail. Because of geometry and service maintenance, RAIM is not always available.

2.10   **Fault detection and exclusion (FDE).** An enhanced version of RAIM employed in some receivers is known as FDE. It uses a minimum of six satellites not only to detect a possible faulty satellite, but to exclude it from the navigation solution so that the navigation function can continue without interruption. The goal of FD is to detect the presence of a positioning failure. Upon detection, proper fault exclusion determines and excludes the source of the failure, without necessarily identifying the individual source of the problem, thereby allowing GNSS navigation to continue without interruption. Availability of RAIM and FDE will be slightly lower for mid-latitude operations and slightly higher for equatorial and high-latitude regions due to the nature of the orbits. The use of satellites from multiple GNSS constellations or the use of satellite-based augmentation system (SBAS) satellites as additional ranging sources can improve the availability of RAIM and FDE.

2.11   **RAIM prediction.** GNSS differs from traditional navigation systems because the satellites and areas of degraded coverage are in constant motion. Therefore, if a satellite fails or is taken out of service for maintenance, it is not immediately clear which areas of the airspace will be affected, if any. The location and duration of these outages can be predicted with the aid of computer analysis and reported to pilots during the pre-flight planning process.

GNSS IMPLEMENTATION ISSUES

2.12   In developing the safety assessment for the GNSS-DME standards, SASP recognized the importance of a number of factors that would affect any implementation of the standards on a global basis. Two of these factors had specific importance in the SASP safety assessment, namely the area of applicability and the equipment eligibility.

2.13   **Communication and area of applicability.** The intent of this guidance material is to support the use of GNSS longitudinal separation in the same manner as DME longitudinal separation. One of the restrictions of distance-based longitudinal separation is that controllers must maintain direct voice communication with aircraft in order to ensure that separation is either maintained or increasing. Therefore, the application is limited to direct controller-pilot VHF voice communication, but not to the type of airspace category. This means that GNSS longitudinal separation can be used even in portions of oceanic and remote airspace, as long as direct controller-pilot VHF voice communication is maintained.

2.14   **Equipment eligibility.** The eligibility for the GNSS longitudinal separation minimum of integrated area navigation (RNAV) systems incorporating GNSS inputs has also been considered. Discussions involved the analysis of how the various types of flight management systems (FMS) worked, and whether it could be assumed that position information from integrated RNAV systems incorporating GNSS input could be regarded as equivalent to GNSS distance. It was agreed that with over 400 different FMS, it would be difficult to speculate how each FMS derives its navigation data. However, after thorough discussion SASP came to the conclusion that any position report derived from an FMS incorporating GNSS would be acceptable, as it would be more accurate than a DME position report.

2.15   **Implementation safety assessment.** In order to ensure that the implementation of GNSS longitudinal separation minima is safe, the appropriate ATS authority must undertake its own implementation safety assessment in addition to the SASP safety assessment to take into account possible local conditions that may not have been covered by the safety assessment work of SASP. For this reason, the safety assessment work carried out by SASP is included in Chapter 3 of this circular, while Chapter 4 indicates what remains to be done by the appropriate ATS authority as part of its implementation safety assessment.

Chapter 3

SASP SAFETY ASSESSMENT FOR GNSS
LONGITUDINAL SEPARATION MINIMA

INTRODUCTION

3.1   This chapter summarizes the safety assessment performed by SASP to determine the GNSS longitudinal separation minima. The methodology is explained below, as are the conclusions drawn from it.

SCOPE

3.2   In the context of the scope of the safety assessment, it is necessary to distinguish between safety assessments undertaken by States for purposes of implementation at local or regional levels and those undertaken by SASP from a global perspective. An assessment undertaken for global purposes does not always contain all the information required to address specific local implementation requirements.

3.3   The difference in assessment scope is depicted in Figure 3-1; it suggests, for example, that because the local operating environment into which GNSS longitudinal separation is to be integrated may have a significant effect on safety, the full safety assessment can be completed only for each local application. As such, the appropriate ATS authority needs to complement the SASP assessment with a regional or local implementation-focused assessment. It should be noted that a local implementation assessment may not necessarily require a regional assessment but may be initiated by an ANSP on a case-by-case basis.
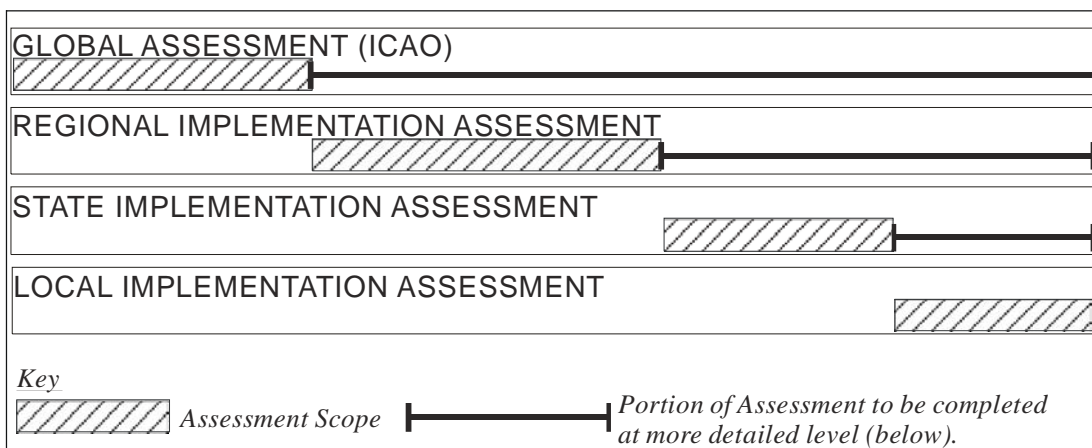

Figure 3-1.   Safety assessment scope

Note 1.— In undertaking a "global" assessment, SASP is not able to assess all the factors that might affect safety during implementation. States should note that the SASP assessment is usually based on a number of assumed characteristics related either to the airspace environment or to aircraft performance. These characteristics may not necessarily be the same as those relevant to any particular regional, State or local implementation.

Note 2.— For regional implementation, a supporting safety assessment should begin with a review of the SASP global assessment taking particular note of the assumed characteristics used in that assessment. Where these characteristics are the same or more stringent than those within the region, then the region needs to focus only on undertaking an assessment of issues related specifically to implementation.

Note 3.— A State implementation assessment need not necessarily follow a regional implementation assessment but could be initiated by a State on its own initiative. In this case, as with the regional implementation assessment, a supporting safety assessment should begin with a review of the SASP global assessment, taking particular note of the assumed characteristics used in that assessment. Where these characteristics are the same or more stringent than those within the State, then the State needs to focus only on undertaking an assessment of issues related specifically to implementation.

Note 4.— A local implementation assessment would normally be a supporting activity for a State implementation assessment and focus specifically on implementation issues such as hazard identification. However, there may be circumstances where the service provider may need to review the SASP global assessment and/or the regional assessment, taking particular note of the assumed characteristics used in that assessment.

OBJECTIVES OF THE SAFETY ASSESSMENT

3.4   The objective of the SASP safety assessment is to demonstrate that the GNSS longitudinal separation minima are safe for application subject to an appropriate implementation safety assessment being undertaken.

ASSUMPTIONS

3.5   SASP made several assumptions during the safety assessment of GNSS with regard to the application of longitudinal separation minima similar to those used by DME. The main assumption made was that in applying longitudinal distance-based separation using GNSS in a manner similar to utilizing DME, only the means of avionics equipment would change when GNSS was used. Therefore:

a)   the requirement of direct VHF voice communication remains unchanged; and

b)   the intended area of application remains unchanged, except for portions of oceanic and remote airspace, provided direct controller-pilot VHF voice communication is maintained.

CONSTRAINTS AND ENABLERS

3.6   Although the SASP assessment was limited to a subset of global common denominators that are independent of a specific operating environment, this has been mitigated by several factors including the fact that GNSS longitudinal separation between two GNSS, or one GNSS and one DME, aircraft is already being applied in three States.

3.7   A compendium of implementation issues and mitigation is provided in the Appendix to this circular, and a State Implementation Roadmap is provided in Chapter 4.

DEVELOPMENT OF SASP ASSESSMENT METHODOLOGY

3.8   In the context of the assessment of the safety of a separation minimum, a distinction is made between risk due to navigation performance and risk due to other hazards. Both safety assessments are described below.

Safety assessment for navigation performance

3.8.1   In order to assess the suitability of GNSS for longitudinal separation, SASP was guided by the *Manual on Airspace Planning Methodology for the Determination of Separation Minima* (Doc 9689). This manual describes two methods for determining whether a proposed system (here, longitudinal separation minima based on GNSS) is safe:

        a)   comparison with a reference system; and

        b)   evaluation of system risk against a threshold.

3.8.2   For the comparison method, the safety of the proposed system is inferred from the safety of the reference system as long as the two systems are sufficiently similar. For the threshold method, the proposed system is considered to be safe when a quantitative estimate of the risk in the proposed system is less than the prevailing threshold value.

3.8.3   Since SASP was not seeking to determine new separation minima, but rather to demonstrate that a different technology could be used to provide existing DME distance-based separation minima, SASP determined that it would be reasonable to compare GNSS performance with the existing DME performance in terms of accuracy of position determination.

3.8.4   GNSS longitudinal separation (the proposed system) envisages using GNSS to provide DME-like separation standards (the reference system). This would suggest that some level of similarity exists. Doc 9689 identifies the minimum requirements for a proposed system to be considered sufficiently similar to a reference system as:

        a)   separation minima must not be less in the proposed system than in the reference system;

        b)   proposed means of communication and surveillance must be no worse in terms of accuracy, reliability, integrity and availability than those in the reference system;

        c)   frequency and duration of the application of minimum separation between aircraft must not be greater in the proposed system than in the reference system; and

        d)   navigation performance (typical and non-typical) of the population of aircraft in the proposed system should be no worse in its effect on collision risk in any dimension than that of the aircraft in the reference system.

3.8.5   For this reason, SASP agreed to undertake a technical comparison using a reference DME system already being used for distance-based separation that was judged to be safe. The view of SASP was that, in the listing in 3.8.4, requirements a) and b) were immediately met because neither the separation minima nor the proposed means of communication and surveillance had changed. Concerning requirement c), it was concluded that the extension of the use of the DME standard to GNSS aircraft did not directly lead to changes to the two parameters of requirement c).

3.8.6   With regard to requirement d), a distinction was made between the increasing use of GNSS and GNSS navigation accuracy proper. The conclusion drawn with regard to the former was that the introduction of more and more aircraft equipped with GNSS was independent of the extension of the use of the DME standard to GNSS aircraft.

3.8.7   A first safety analysis to evaluate the impact of GNSS navigation accuracy using the comparative safety assessment method was presented in SASP-WG/WHL/3–WP/8. One issue identified as requiring further work, was that

separation differed between aircraft reporting GNSS and DME distances when the aircraft reporting GNSS distance was closer to the NAVAID and was on the same side of the NAVAID as the DME aircraft. This is a consequence of the difference in nature of the error characteristics of GNSS and DME distance reporting.

3.8.8   The issue was addressed in SASP-WG/WHL/4-WP/16. However, different risk measures were used and different conclusions were drawn in the main text of WP/16 and in an attachment to it. The risk measure used in the main text was a deterministic range for the true distance between a pair of aircraft given a reported distance difference equal to 20 NM. The other risk measure was probabilistic, namely the probability that the true distance between the aircraft is larger than 20 NM given a reported distance difference of 20 NM. The SASP Mathematicians sub-group (MSG) concluded that the analysis in WP/16 did not prove that the GNSS/DME case was always safer than the DME/DME case.

3.8.9   The MSG then developed an alternative risk measure, namely the probability of an aircraft pair actually being in longitudinal overlap given a reported distance difference of 20 NM. Initial results seemed to support the conclusion that the use of DME and GNSS in combination to establish a distance-based separation minimum would be no less safe than when both aircraft reported their distances by DME. It was agreed that a more robust formal safety assessment would be prepared for the next SASP meeting.

3.8.10   During the preparation of this safety assessment, it became clear that the analysis had to be extended to include variations in true airspeed (TAS) of the aircraft in a pair. As a result, the risk measure needed to be refined, namely as to the probability of an aircraft pair experiencing a longitudinal overlap over a certain time interval given a reported distance difference of 20 NM or more. Initial calculations suggested that the comparative assessment applied to the refined longitudinal overlap probabilities indicated that GNSS/DME would not be safer than DME/DME (at least for the case of Gaussian probability distributions).

3.8.11   It was agreed at SASP-WG/WHL/5, therefore, that it would be more appropriate to perform a full collision risk assessment (i.e. apply the threshold method) than to compare longitudinal overlap probabilities in a comparative assessment. The key parameter for the collision risk model would still be the probability of longitudinal overlap for an aircraft pair.

3.8.12   The development of a full collision risk model started at SASP-WG/WHL/5 and was completed with the following model in WP/23 of SASP-WG/WHL/7:

$$N_{ac}^* = 2 \times P_x[0, t_{end}] P_y(0) P_z(0) \left\{ 1 + \frac{\lambda_x}{\lambda_y} \frac{\overline{|v_y|}}{|\Delta V_x|} + \frac{\lambda_x}{\lambda_z} \frac{\overline{|v_z|}}{|\Delta V_x|} \right\}$$

where

N_{ac}^* is the expected number of accidents for a single aircraft pair being separated longitudinally, and

$P_x[0, t_{end}]$ is the probability that an aircraft pair will experience the start of a longitudinal overlap during the time interval $[0, t_{end}]$.

3.8.13   The other symbols in the collision risk model above have their usual meaning.

3.8.14   The above collision risk model could be used for the method called "evaluation of system risk against a threshold" in Doc 9689, but two complicating factors were identified. First, there was some argument as to which value for the risk threshold should be used for the type of airspace environment in which the new minimum would be applied. Second, and perhaps more important, the probability of longitudinal overlap $P_x[0, t_{end}]$ depends on the probability distribution of reported distances between aircraft in a pair. It was not possible to come up with a realistic model for this distribution.

3.8.15   Therefore, it was decided to evaluate once more the ratio of the longitudinal overlap probabilities for GNSS/DME and DME/DME aircraft pairs, i.e. a "comparison with a reference system" type of assessment. This was on the assumption that the same distribution of reported distances would apply to GNSS/DME and DME/DME aircraft pairs and would cancel each other out in a relative comparison. The resultant hybrid safety argument is summarized below. Full details may be found in SASP-WG/WHL/7-WP/23 and Appendix I to SASP-WG/WHL/7-SD.

3.8.16   It was found that for distances of the aircraft pairs to the DME station larger than a specific value, the longitudinal overlap probabilities for a GNSS/DME aircraft pair were smaller than those for a DME/DME aircraft pair at each distance. Thus, for these larger distances, the GNSS/DME case was considered to be safe on the assumption that the DME/DME case was safe.

3.8.17   It was also found that for distances smaller than the specific value, the longitudinal overlap probabilities for a GNSS/DME aircraft pair were not uniformly smaller than those for a DME/DME aircraft pair at each distance. However, the longitudinal overlap probabilities were effectively negligible, i.e. any collision risk estimate based on these values and the above collision risk model would meet any reasonable value of the risk threshold. Thus, for these smaller distances, the GNSS/DME case was also considered to be safe.

Hazard assessment

3.8.18   The SASP safety assessment comprises two parts, namely, the risk due to navigation performance and the risk due to other hazards. With the safety assessment for navigation performance having been described above, the following deals briefly with the safety assessment for the other hazards.

3.8.19   In an effort to identify hazards that may affect the implementation and use of published separation minima and to develop effective controls for these hazards, SASP undertook a process of hazard identification. The intent of this activity was to include operational experience and issues in the development of a separation minimum. The identified hazards are documented in the implementation issues and mitigation log in the Appendix to this circular.

Note.— SASP hazard identification is limited in its scope and is intended to identify significant globally applicable hazards and to develop specific controls that will be considered in separation minima development. This activity should not be considered as a formal hazard identification process that would normally include the determination of severity and estimates of likelihood and requires complementary regional, State or local implementation safety assessment action.

REFERENCE MATERIAL

3.9   The working papers summarizing the safety assessment described in 3.6 are as follows:

Meeting	Working Paper	Title
SASP-WG/WHL/3	8	Safety analysis using a reference system methodology for longitudinal separation minima based on GNSS.
SASP-WG/WHL/4	16	Allowing position reports for the purpose of longitudinal separation between aircraft providing GNSS and DME distances when the aircraft providing GNSS distances is closer to the NAVAID.

Meeting	Working Paper	Title
SASP-WG/WHL/4	17	Safety analysis using a reference system methodology for longitudinal minima based on GNSS.
SASP-WG/WHL/5	23	Proposed wording for amendment to Doc 4444 – 5.4.2.3 Longitudinal Separation Minima based on distance reports using DME and GNSS.
SASP-WG/WHL/7	23	GNSS DME Safety Assessment.

CONCLUSIONS

3.10   The application of the SASP process demonstrated that the separation minima developed and detailed in this document have been determined as being safe. SASP also identified a number of hazards together with appropriate mitigations and controls.

3.11   Notwithstanding the above, there is a requirement for a region or State to undertake an implementation safety assessment. In principle, this comprises two parts, namely a safety assessment for navigation performance and a hazard assessment. In practice, only a hazard assessment needs to be performed for any local implementation since the safety assessment for GNSS navigation performance is valid for any implementation. The goal of the hazard analysis is to identify hazards and related mitigation measures that are specific to the local situation.

3.12   To assist regions and States with their implementation of the safety assessment, a State implementation plan is provided in Chapter 4. This plan relies upon the various outputs from the application of the SASP safety assessment.

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Chapter 4

IMPLEMENTATION CONSIDERATIONS

INTRODUCTION

4.1   In order to be able to implement a PANS-ATM separation minimum, a regional, State or local safety assessment must be completed (see Chapter 3, 3.2). When undertaking this activity, reference should be made to the requirements detailed in Annex 11 — *Air Traffic Services* (Section 2.27), the *Procedures for Air Navigation Services — Air Traffic Management* (PANS-ATM, Doc 4444) (Section 2.6), and the guidance material contained in the ICAO *Safety Management Manual (SMM)* (Doc 9859).

4.2   This chapter provides an overview of the minimum steps that SASP considers necessary for a region, State or local authority to undertake a safety assessment.

PROCESS

4.3   When undertaking a regional, State or local safety assessment, the following process is provided as guidance:

Step 1:   Undertake widespread regional consultation with all possible stakeholders and other interested parties, where required (an example of a region would be the NAT or CAR/SAM);

Step 2:   Develop an airspace design concept or ensure that the proposed standard being implemented will fit the current airspace system;

Step 3:   Develop suitable safety assessment documentation including a safety plan, where required (Note.— A safety plan may not always be necessary.);

Step 4:   Undertake safety management activities including:

a)   formal hazard identification and analysis; and

b)   simulation where appropriate.

Step 5:   Develop suitable risk controls and mitigators for identified hazards;

Step 6:   Identify training and operational approval requirements and develop an implementation plan and training materials; and

Step 7:   Develop suitable post-implementation monitoring and review processes.

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Appendix

HAZARD AND MITIGATION LOG

This Appendix lists a number of hazards that were considered by SASP when developing the GNSS longitudinal separation minima. The pertinent ATS authority must, in its implementation safety assessment, review these hazards and reflect how they may affect its local implementation and, additionally, identify if there are other State or local hazards that need to be considered (refer to Chapter 3, 3.2).

HAZARD 1

HOW OFTEN ARE VALUES CLOSE TO THE SEPARATION MINIMA USED IN PRACTICE?

Aircraft are very rarely if ever spaced by the longitudinal separation minimum. It would be impractical to verify each aircraft's progress so frequently in order to ensure that the minimum separation is maintained or increasing. Therefore distances that are close to the minima may more often be used to effect altitude changes as opposed to in-trail same level separation. This is done by issuing altitude restrictions such as "*maintain an altitude until a certain distance*" or "*reach an altitude by a certain distance*". Controllers can clear aircraft to the same level only once position reports indicate that the minimum exists. When the clearance is issued, the actual spacing between the aircraft is much more than the minimum in practice.

Risk

Loss of separation. The acceptance of GNSS position reports for the purpose of longitudinal separation will result in aircraft being separated by less than the specified minimum.

Analysis

It is important to note that controllers are not required to determine the actual ground distance between any two aircraft when applying longitudinal distance-based separation because the application requires the following:

Establish longitudinal separation on the basis of DME position reports.

Therefore, controllers do not actually have to ensure that aircraft are spaced geographically by the appropriate minimum. They authorize aircraft to operate at the same level and issue clearances to climb or descend through the altitude of another aircraft once position reports indicate that the required minimum is being met; the actual spacing between aircraft is in fact typically much greater than this required minimum.

SASP global controls and/or mitigators

The following examples demonstrate the application of longitudinal distance-based separation.

Same direction — two aircraft en-route:

In practice controllers obtain the distance from the leading aircraft first when applying longitudinal separation. This ensures extra separation in addition to the minimum standard (20 NM), because as controllers go through the process of confirming position information from the second aircraft (the one following the leading aircraft), the leading aircraft continues to gain distance from its original position. This procedure ensures additional spacing, one that is always larger than the required 20 NM.

Same direction — two departing aircraft:

The first departing aircraft must report 20 NM from the airport before the second departing aircraft can receive its departure clearance. The time it may take before the second aircraft actually departs increases the actual spacing between these two aircraft.

Same direction — departing aircraft and an enroute aircraft:

A position report of 20 NM from the aerodrome complex is required from the enroute aircraft before the departing aircraft can obtain its departure clearance. The time it may take before the departing aircraft actually takes off increases the actual spacing between these two aircraft.

Opposite direction — en-route:

This separation is issued between opposite direction aircraft that are initially separated by a vertical minimum. The application requires that aircraft provide position reports that satisfy a 10-NM spacing. If a position report of an inbound aircraft indicates 24 NM from a common point, then the clearance to the outbound aircraft will impose a restriction to be vertically separated until 34 NM from the common point. By the time the outbound aircraft passes 34 NM, the inbound aircraft has in reality travelled much, much farther in the opposite direction. Therefore when the outbound aircraft passes through the altitude of the inbound aircraft it is separated by a much larger distance than 10 NM.

Other considerations:

As a result of TO-TO navigation (see explanation under Hazard 3), it may take more time to obtain position reports from a GPS-equipped aircraft that is proceeding away from a DME facility or waypoint than from a DME-equipped aircraft. This may therefore result in greater separation between aircraft whenever the following aircraft is equipped with GNSS. If the leading aircraft is equipped with GNSS there is no change.

State and local controls and/or mitigators required

1. All instances of loss of separation related to this separation minimum must be reported and investigated.

2. The ATS authority intending to apply this separation must ensure that the airspace and route design is such that the application of this separation is practicable.

3. The ATS authority intending to apply this separation must ensure that the amount of traffic is not more than can be safely handled by this type of separation.

HAZARD 2

COMMUNICATION CAPABILITY/AREA OF APPLICABILITY

The applicability of DME longitudinal separation is limited by the virtue of the DME service range. Typically, separation can only be applied within a 200-NM radius of a DME facility. Subsequently, DME separation is restricted to an area of limited airspace. The GNSS signal is available globally, and its accuracy is uniform regardless of airspace category.

Risk

Application of the minima in oceanic and remote airspace beyond direct pilot-controller VHF communications. The concern is that controllers may apply the new GNSS longitudinal separation with any type of direct controller-pilot communication (DCPC), including "data link".

Analysis

It is intended to use GNSS separation in the same manner as DME longitudinal separation. One of the restrictions of distance-based longitudinal separation is that controllers must maintain direct voice communication with pilots in order to ensure that separation is either maintained or increasing. This limitation is commonly known as DCPC. The project team was informed that in some ICAO documents DCPC includes data link. The recommendation by SASP is not to allow data link communication for GNSS longitudinal separation.

SASP global controls and mitigators

PANS-ATM, 5.4.2.3, Longitudinal separation minima based on distance using DME and/or GNSS, was amended to emphasize that voice communication shall be used. The amended text states: *This type of separation shall be applied between two aircraft using DME, or two aircraft using GNSS, or one aircraft using DME and one aircraft using GNSS. Direct controller-pilot VHF voice communication shall be maintained while such separation is used.* While the limitation of communication transmitters is a "constraint" to where GNSS longitudinal separation can be applied, inserting GNSS longitudinal separation minima in the existing 5.4.2.3, rather than creating a new paragraph, reinforces that this type of separation is to be applied in the same manner as the current DME longitudinal separation. Basically, whatever controllers are able to do with DME-equipped aircraft can now be accomplished with GNSS-equipped aircraft.

State and local controls and/or mitigators required

The appropriate ATS authority must in the implementation safety assessment determine in each area of application the required quality of communication for the application of the GNSS longitudinal separation minimum.

Prior to and during the application of this separation minimum, the controller must consider the adequacy of the available communications, considering the time element required to receive replies from two or more aircraft, and the overall workload/traffic volume associated with the application of such minimum.

HAZARD 3

GNSS NAVIGATION

The GNSS receiver functions differently from conventional avionics receivers in that it presents data in reference to the waypoint the aircraft is approaching. Once an aircraft passes this waypoint, the GPS receiver again sequences the next waypoint as the "active" waypoint, and all information displayed is in reference to this new waypoint. This is referred to as "TO-TO" navigation.

Risk

Loss of separation. By not understanding how GPS navigation works, controllers may apply GNSS longitudinal separation incorrectly.

Analysis

The GNSS receiver functions differently compared to conventional avionics receivers.

1. Some aircraft navigating using GNSS are not capable of flying an outbound track from a waypoint. Those aircraft always have to track towards a waypoint.

2. In some cases, after passing fly-over waypoints, the aircraft will not join a track from the fly-over waypoint but rather join a track direct towards the next waypoint.

While the concept of TO-TO navigation may pose a potential hazard, the safety analysis shows that technical risks are limited. The change from the old TO-FROM navigation to the new TO-TO navigation introduces changes to the pilot's perspective in regard to tools, tasks and associated procedures used, and this also applies to how the controller must apply the separation. Those issues need to be addressed by means of training and awareness initiatives.

SASP global controls and/or mitigators

Pilots are being advised by means of aeronautical information circulars (AICs) or State aeronautical information publications (AIPs) that position reports from other than TO waypoints may be requested by air traffic control (ATC) for the purpose of longitudinal separation. To this end, pilots are being reminded to be familiar with their avionics equipment so that this information can be provided as soon as practicable.

Controllers should be briefed about this GNSS limitation.

State and local controls and/or mitigators required

1. Any risk associated with the different behaviour of the GNSS system as opposed to conventional VOR/NDB/DME systems should be mitigated by means of training and awareness initiatives. This is the responsibility of the appropriate ATS authority.

2. Pilots should be advised by means of AICs or State AIPs that position reports from other than TO waypoints may be requested by ATC for the purpose of track and distance-based separation. To this end, pilots should be reminded to be familiar with their avionics equipment so that this information can be provided as soon as practicable. It is the responsibility of the appropriate ATS authority to issue the appropriate guidance material to pilots. Following is an example of a suitable text for this purpose:

    GNSS avionics typically display the distance to the next waypoint. To ensure proper separation between aircraft, a controller may request the distance from a waypoint that is not the currently-active waypoint in the avionics; it may even be behind the aircraft. Pilots should be able to obtain this information from the avionics. Techniques vary by manufacturer, so pilots should ensure familiarity with this function.

HAZARD 4

DME SLANT RANGE

DME measures distances between the aircraft and the DME facility in a straight line — this is known as slant range. As the aircraft gets closer to the DME facility, the slant range produces errors; this is known as slant range error. Basically, an aircraft flying at 15 000 ft reporting 14 DME, is only 13.78 NM along the ground from the DME facility. On the other hand GNSS is not subject to slant range error, and GNSS distance reports always represent the true ground distance between the aircraft and the waypoint.

Risk

Loss of separation. DME slant range may pose a risk to longitudinal separation between a mix of DME- and GNSS-equipped aircraft only when the GNSS aircraft is closer to the DME facility.

Detailed analysis of some distance measuring scenarios showed that there might be a higher probability that the true separation is at least 20 NM when both aircraft are reporting distances using DME, compared to aircraft using GNSS and DME.

Analysis

The analysis presents only a probability that the true separation being at least 20 NM between GNSS/DME aircraft pairs is lower than between two DME aircraft. It is not conclusive that the actual separation of the GNSS/DME pair would result in less than the required minimum. This hazard is adequately addressed under Hazard 1 of this matrix "How often are values close to the separation minima used in practice". In actual scenarios, resulting longitudinal separation between aircraft, whether DME/DME, GNSS/GNSS or GNSS/DME, is always far greater than the required minimum. Therefore the issues that need to be addressed are:

       1)   Is the true separation produced by the GNSS/DME aircraft pair acceptable?; and

       2)   How does this compare to what is traditionally accepted from the DME/DME aircraft pairs in other longitudinal separation scenarios?

SASP global controls and/or mitigators required

The methods by which different types of longitudinal separation are applied inherently assure that aircraft will be separated by greater than the required 20- or 10-NM minimum.

See explanation under Hazard 1 of this hazard and mitigation log.

HAZARD 5

FREQUENCY AND DURATION OF THE APPLICATION OF MINIMUM SEPARATION BETWEEN AIRCRAFT MUST NOT BE GREATER IN THE PROPOSED SYSTEM THAN IN THE REFERENCE SYSTEM

The frequency and duration of the application of minimum separation will not be affected by the implementation of the proposed system.

Risk

Greater exposure to loss of separation if frequency and duration of the application of minimum separation are greater in the proposed system. No change between the proposed system and the reference system is perceived in this respect. No additional risk is perceived.

Analysis

Nil.

SASP global controls and/or mitigators

Nil.

State or local controls and/or mitigators required

Nil.

HAZARD 6

DATABASE INTEGRITY

Database integrity issues are common to all aspects of area navigation and therefore to the application of all separation minima that employ reporting by means of RNAV avionics.

Risk

Loss of separation. A lack of database integrity may result in incorrect waypoint information in the navigation database.

Analysis

Database integrity issues are common to all aspects of area navigation and to the application of all separation minima that employ area navigation. This issue is therefore not specific to the application of GNSS longitudinal separation.

With the implementation of RNAV procedures based on GNSS, the handling of navigation data is a significant aspect of safe operations. Its importance increases as operations move away from traditional procedures and routes based on flying "to and from" ground-based navigation aids. Errors can occur throughout the entire data chain, commencing with surveying, through procedure design, data processing and publication, data selection, coding, packing processes and up to the replacement of onboard data. The latter occurs as often as every 28-day AIRAC cycle and in the future may become a near real-time activity.

Database integrity rests on the assumption that the chain of activity, from surveying through loading the data into aircraft databases, will deliver correct data into the aircraft navigation systems.

International efforts are currently in progress to ensure database integrity by the introduction of new database quality control procedures. Refer to RTCA DO-200A "Standards for processing aeronautical data" for information about this issue.

SASP global controls and/or mitigators

Nil.

State or local controls and/or mitigators required

The appropriate ATS authority must ensure that appropriate quality control procedures are followed at all levels of the data chain to ensure database integrity.
Reference: RTCA DO-200A

HAZARD 7

NAVIGATION PERFORMANCE OF THE POPULATION OF AIRCRAFT IN THE PROPOSED SYSTEM SHOULD BE NO WORSE IN ITS EFFECTS ON COLLISION RISK, IN ANY DIMENSION, THAN THAT OF THE AIRCRAFT IN THE REFERENCE SYSTEM

Navigation performance of the population of aircraft in the proposed system is similar in its effects on collision risk, in any dimension, to that of the aircraft in the reference system.

Risk

No change between the proposed system and the reference system is perceived in this respect. No additional risk is perceived.

Analysis

Nil.

SASP global controls and/or mitigators

Nil.

State and local controls and/or mitigators required

Nil.

HAZARD 8

WAYPOINT USE

With the multitude of fixes stored in the GNSS receiver database, there is a chance that pilots may derive distance information in reference to the "wrong" waypoint. The possibility of such error is not as likely when using DME because there is no database associated with a DME receiver, pilots simply dial in the DME frequency and read the displayed distance.

Risk

Loss of separation. There is some likelihood that pilots may provide distance in reference to the wrong waypoint. The resulting position information will be erroneous and could very easily lead to loss of the required separation.

Analysis

Database issues cover two risks:

1. Database integrity (refer to Hazard 6); and

2. The possibility that a pilot will provide distance in reference to an incorrectly selected waypoint or fly a track to an incorrectly selected waypoint.

For both cases the resulting position information will be erroneous and could result in loss of separation.

This risk exists with the application of any RNAV-type procedure. There are numerous procedures that require pilots to navigate to waypoints and report distances or progress in regard to waypoints imbedded in their databases. When GNSS longitudinal separation is used between any two RNAV aircraft, the separation can be erroneous when one or both aircraft report the distance or track in regard to the wrong waypoint. With respect to providing distance information by means of DME equipment, it has been pointed out that several new aircraft types select the DME automatically, and unless pilots verify the channel of the DME manually, the resulting distance may also be erroneous. Pilots must be vigilant in following procedures with any type of equipment.

Database issues are common to any RNAV operation; they do not pose any greater risk to GNSS longitudinal separation than to other separation, which is based on deriving position reports from waypoints.

It is important that controllers and pilots use standard phraseology when obtaining and giving track and distance reports. This helps to minimize the possibility of errors.

SASP global controls and/or mitigators

SASP has created specific phraseology for obtaining and reporting GNSS tracks and distances. This phraseology is published in the PANS-ATM.

State and local controls and/or mitigators required

1. Pilots and controllers should be advised by means of their respective directives, circulars, manuals and training of the importance of including the name of the waypoint when reporting the distance to and/or from that waypoint.

2. Appropriate ATC training is required to make controllers appreciate the significance of using distances with reference to incorrect waypoints. To this end, the training curriculum should include the definition of "Common Point" (which is defined in PANS-ATM).

HAZARD 9

EQUIPMENT ELIGIBILITY

The safety analysis used for determining GNSS longitudinal separation was based on a comparative assessment between GNSS and DME, not RNAV. The hazard exists that aircraft with RNAV not incorporating GNSS will take advantage of this separation minima.

Risk

Loss of separation. There is a possibility that controllers may inadvertently use RNAV position reports, instead of GNSS position reports, for the application of GNSS longitudinal separation. Since RNAV distance reports are not necessarily as accurate as those based on GNSS, aircraft may not be separated by the required minimum.

Analysis

Discussions regarding this issue involved the analysis of how the various types of FMS work, and whether it could be assumed that position information from integrated RNAV systems incorporating the GNSS integrated navigation system could be regarded as equivalent to GNSS distance. It was agreed that with over 400 different FMS, it would be impossible to determine how each FMS derives its navigation data.

Mitigation

Since this comparative assessment did not include RNAV navigation accuracy, it is not known what type of errors could be introduced by such reports and subsequently whether longitudinal separation could be compromised.

Discussions in SASP regarding this issue involved the analysis of how the various types of FMS work, and whether it could be assumed that navigation and position information from integrated RNAV systems incorporating GNSS input could be regarded as equivalent to GNSS navigation and distance. It was agreed that with over 400 different FMS, it would be impossible to determine how each FMS derives its navigation data. After thorough discussion, the SASP came to the conclusion that any navigation and position information derived from an FMS incorporating GNSS input would be more accurate than DME position information.

The feedback from human factors experts was unanimous in agreeing that it could not be expected that all pilots involved would adhere to the requirement to use only GNSS-derived distance for the application of GNSS longitudinal separation, even after careful training and with sufficient operational experience. Therefore it would be realistic to expect that less accurate RNAV or FMS distances would sometimes be reported. Nevertheless, it was the consensus of SASP that the risk of this situation occurring was tolerable with the proposed mitigation being that the controller request "GNSS" distance when in doubt.

SASP global controls and/or mitigators

1. The following Note was added to 5.4.2.3.1 of PANS-ATM to clarify which navigation system could be regarded as equivalent to GNSS position accuracy.

"Note.— For the purpose of applying GNSS-based separation minimum, a distance derived from an integrated navigation system incorporating GNSS input is regarded as equivalent to GNSS distance."

2. Phraseology has been added to the PANS-ATM for the controller to specifically request "GNSS distance" when obtaining a GNSS-derived distance report.

State and local controls and/or mitigators required

The appropriate ATS authority should include the foregoing mitigations in flight crew and controller training programmes.

HAZARD 10

HUMAN FACTORS

The feedback from human factors experts was unanimous in stating that it cannot be expected that all pilots involved would adhere to the requirement to use only GNSS-derived distance for the application of GNSS longitudinal separation, even after careful training and with sufficient operational experience. Therefore it is realistic to expect that less accurate RNAV or FMS distances will be reported.

Risk

Loss of separation. Controllers may inadvertently use less accurate RNAV position reports in place of GNSS position reports for the application of the proposed GNSS longitudinal separation which would result in less than the separation minima being used.

Analysis

Pilots must be made aware that no possible ambiguity can be permitted regarding which type of navigation system is being used to provide distance information.

SASP realized the importance of relaying the right information to the aviation community about the significance of the type of navigation system being used for certain types of separation. It was agreed that distance reports from navigation systems not incorporating GNSS could not be used to establish GNSS separation minima. To this end the text in the proposed amendment to PANS-ATM had to make this point very clear.

SASP global controls and/or mitigators

New text was added to PANS-ATM to clarify that:

  a) other RNAV distance reports are not acceptable to establish the proposed separation minima;

  b) controllers shall specifically request "GNSS distance" if any ambiguity exists about which navigation sensor is providing the distance information;

  c) States ensure that pilots are made aware that only GNSS distance reports are acceptable for certain types of longitudinal separation minima;

  d) pilots inform ATC when they are unable to provide distance based on GNSS; and

  e) pilots are explained the circumstances under which distance based on GNSS is not to be provided.

The following Note was added to 5.4.2.3.1 to clarify which navigation system could be regarded as equivalent to GNSS position accuracy.

"Note.— For the purpose of applying GNSS-based separation minimum, a distance derived from an integrated navigation system incorporating GNSS input is regarded as equivalent to GNSS distance."

As well PANS-ATM states the following:

"5.4.2.3.2   When applying these separation minima between any aircraft with area navigation capability, controllers shall specifically request GNSS-derived distance.

Note.— Reasons making a pilot unable to provide GNSS distance information may include inadequate on-board equipment, no GNSS input into an integrated navigation system, or a loss of GNSS integrity."

Phraseology has been added to PANS-ATM for the controller to specifically request "GNSS distance" when obtaining a GNSS-derived distance report.

State and local controls and/or mitigators required

The appropriate ATS authority should include the foregoing mitigations in flight crew and controller training programmes.

HAZARD 11

**POTENTIAL DIFFERENCE BETWEEN THE COORDINATES OF A DME STATION
AND ANY COLLOCATED WAYPOINT**

When separating a mix of GNSS/DME-equipped aircraft there is a possibility that RNAV waypoints may not exactly overlay the position of the DME navigation aid.

Risk

Loss of separation. When RNAV waypoints are not exactly collocated with the DME navigation aid, the resulting distance might be less than required by the separation minimum.

Analysis

If the RNAV waypoint is not collocated with the position of the VOR/NDB/DME then the aircraft would not be measuring distance from a common point as is required for this separation. The resulting distance between the aircraft might therefore be less than the required separation.

Where the airborne database "overlays" a waypoint on top of a ground-based navigation aid, the database encoders have no other choice than to use the official AIRAC coordinates for that navigation aid. When the Aeronautical Information Service (AIS) establishes a waypoint in the same location as a navigation aid, the process necessitates the use of the navigation aid's defined coordinates. It is therefore highly unlikely that there would be any intentional discrepancies.

While it cannot be guaranteed that waypoints and navigation aids are collocated in all instances, it is believed that this issue does not pose a significant risk to longitudinal separation between a mix of DME and GNSS aircraft, as the errors between the waypoints and fixes formed by ground-based navigation aids, for example, are typically very small. Procedures to minimize this risk are well outlined in Annex 15 as well as in RTCA DO-200A and RTCA DO-201 (Processing Aeronautical Information).

SASP global controls and/or mitigators

ICAO documentation contains information on the steps to be followed to ensure the collocation of the coordinates of the waypoints and existing navigation aid coordinates. The process of publishing waypoints undergoes scrupulous integrity checking. It is the consensus of SASP that the procedures in place currently to assure accuracy as outlined above are sufficient to bring the risk to an acceptable level.

State and local controls and/or mitigators required

1. The appropriate ATS authority must define and document for the controllers' use which RNAV waypoints and navigation aids are to be considered a common point.

2. ICAO documentation contains information on the steps to be followed to ensure the collocation of the coordinates of the waypoints and existing navigation aid coordinates. The process of publishing waypoints undergoes a scrupulous integrity checking.

HAZARD 12

PHRASEOLOGY

Does existing phraseology enable ATC to distinguish which navigation systems are deriving position reports?

Risk

Loss of separation. Existing phraseology for requesting or reporting position reports does not enable ATC to determine which navigation systems or sensors are being used for position determination, e.g. RNAV not incorporating GNSS or RNAV incorporating GNSS.

Analysis

A review of PANS-ATM Chapter 12, Phraseology, revealed that existing phraseology to "request" or to "relay" position reports does not enable ATC to determine whether RNAV or GNSS sensors are being used for position determination.

SASP global controls and/or mitigators

SASP has created standard phraseologies for the application of GNSS-based separation to allow ATC to request position reports with respect to specific navigation systems. Those phraseologies are published in the PANS-ATM.

State or local controls and/or mitigators required

The appropriate ATS authority should enforce the use of standard phraseologies in pilot-controller communications.

— END —