

**Cir 321
AN/183**



Guidelines for the implementation of GNSS longitudinal separation minima

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

International Civil Aviation Organization

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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

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.

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:

<i>Typical operation</i>	<i>Horizontal alert limit</i>
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 LONGITUDINAL 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.

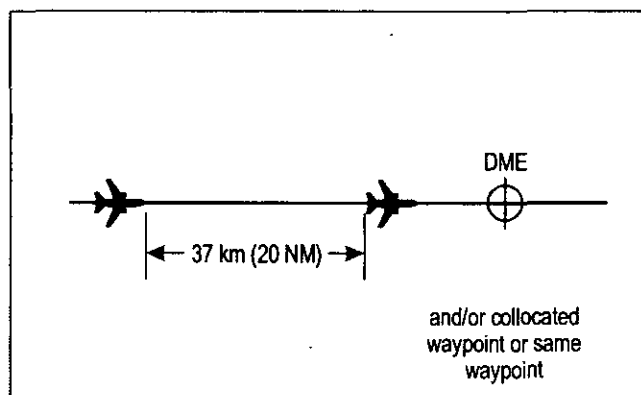


Figure 5-21. 37 km (20 NM) DME and/or GNSS-based separation between aircraft on same track and same level (see 5.4.2.3.3.1 a))

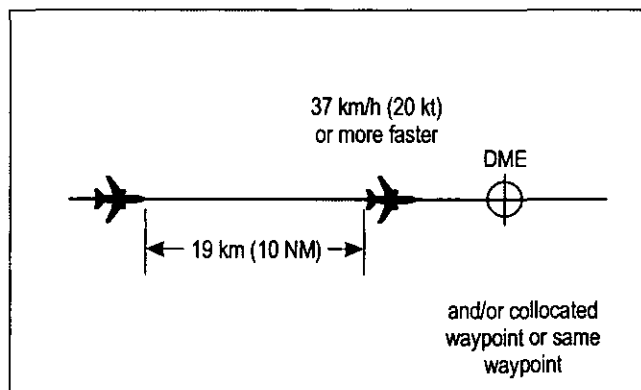


Figure 5-22. 19 km (10 NM) DME and/or GNSS-based separation between aircraft on same track and same level (see 5.4.2.3.3.1 b))