Cir 325
AN/187

In-Trail Procedure (ITP) Using Automatic Dependent Surveillance — Broadcast (ADS-B)

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ABBREVIATIONS AND ACRONYMS

ADS-B	Automatic dependent surveillance — broadcast
AIS	Aeronautical information service
ATC	Air traffic control
ATS	Air traffic service
ATSA	Air traffic situational awareness
CPDLC	Controller-pilot data link communications
EUROCAE	European Organisation for Civil Aviation Equipment
GNSS	Global navigation satellite system
HF	High frequency
ITP	In-trail procedure
MOPS	Minimum operational performance standards
NM	Nautical mile
OpsSpecs	Operations specifications
PF	Pilot flying
PNF	Pilot not flying
RA	Resolution advisory
Resp.	Respectively
SASP	Separation and Airspace Safety Panel
SASP MSG	SASP Mathematical Sub-Group
SATCOM	Satellite phone communications
SLOP	Strategic lateral offset procedures
SOP	Standard operating procedure
SPR	Safety and performance requirements
VHF	Very high frequency

GLOSSARY

Note.— References followed by an asterisk (*) can be found in proposed Amendment 6 to the Procedures for Air Navigation Services — Air Traffic Management *(PANS-ATM, Doc 4444) (applicable November 2014).*

Closing ground speed. The difference between the ITP aircraft's ground speed and a reference aircraft's ground speed, used to determine the reduction in ITP distance.

Closing Mach speed. The difference between the ITP aircraft's Mach speed and a reference aircraft's Mach speed used to determine the reduction in ITP distance.

Free text message element. A message element used to convey information not conforming to any standardized message element in the CPDLC message set.

ITP aircraft. An aircraft approved by the State of Operator to conduct in-trail procedure (ITP).

ITP distance. The distance between the ITP aircraft and a reference aircraft as defined by:

a) aircraft on the same track, the difference in distance to an aircraft calculated common point along a projection of each other's track; or

b) aircraft on parallel tracks, the distance measured along the track of one of the aircraft using its calculated position and the point abeam the calculated position of the other aircraft.

Note.— Reference aircraft refers to one or two aircraft with ADS-B data that meet the ITP criteria described in the Procedures for Air Navigation Services — Air Traffic Management *(PANS-ATM, Doc 4444), 5.4.2.7,* and are indicated to ATC by the ITP aircraft as part of the ITP clearance request.*

ITP equipment. All avionics which are involved in the execution of ITP functions needed to support or perform the ADS-B in-trail procedure (ITP).

Preformatted free text message element. A free text message element that is stored within the aircraft system or ground system for selection.

Standardized free text message element. A message element that uses a defined free text message format, using specific words in a specific order.

Note.— Standardized free text message elements may be manually entered by the user or pre-formatted.

REFERENCES

ICAO publications:

Annex 10 — *Aeronautical Telecommunications,* Volume II — *Communication Procedures including those with PANS status*
Procedures for Air Navigation Services — Air Traffic Management (PANS-ATM, Doc 4444)
Procedures for Air Navigation Services — Aircraft Operations (PANS-OPS, Doc 8168)
Safety Management Manual (SMM) (Doc 9859)
Manual on Airborne Surveillance Applications (Doc 9994) (draft)
Global Operational Data Link Document (GOLD), 2nd Edition

Other publications:

European Organisation for Civil Aviation Equipment (EUROCAE)

Safety, Performance and Interoperability Requirements Document for ATSA-ITP Application, Doc ED-159 and Supplement

Minimum Operational Performance Standards (MOPS) for Aircraft Surveillance Applications (ASA) System, Doc ED-194

RTCA

Safety, Performance and Interoperability Requirements Document for the In-Trail Procedure in Oceanic Airspace (ATSA-ITP) Application, DO-312

Minimum Operational Performance Standards (MOPS) for Aircraft Surveillance Applications (ASA) System, DO-317A and Supplement

Note.— RTCA documents DO-312 and DO-317A and Supplement are available for purchase from RTCA, Inc., 1150 18th Street NW, Suite 910, Washington, DC 20036. Tel.: (202) 833-9339. www.rtca.org.

Chapter 1

OVERVIEW

Note.— References followed by an asterisk (*) can be found in proposed Amendment 6 to the Procedures for Air Navigation Services — Air Traffic Management *(PANS-ATM, Doc 4444) (applicable November 2014).*

1.1 INTRODUCTION

The purpose of this document is to provide information on the in-trail procedure (ITP), its separation minimum and the work undertaken by ICAO in this regard. It is aimed at civil aviation authorities and service providers worldwide who are responsible for implementing ITP.

1.2 BACKGROUND

1.2.1 At the Tenth Meeting of the Separation and Airspace Safety Panel Working Group of the Whole (SASP WG/WHL/10, November 2006), the panel was advised that the Air Navigation Commission had requested that SASP, among other panels, be directly involved in assisting the Aeronautical Surveillance Panel (ASP) in the progression of a work programme focused on airborne surveillance applications.

1.2.2 The work programme included the development of ITPs that would enable reduced separation minimum to be used in planned flight trials. The use of airborne surveillance applications such as ITP would facilitate climb and descent of aircraft during the en-route phase to enable better use of optimal flight levels in environments where a lack of air traffic surveillance service or the application of large separation minima was a limiting factor. The system benefit of ITP is significant fuel savings, enabling greater payloads to be uplifted. In some situations, ITP also allows the pilot to more readily achieve an operationally desirable flight level, as in situations where persistent turbulence exists along the planned flight route.

Note.— The benefit analysis of the EUROCONTROL CRISTAL ITP project indicated that ITP has the potential to provide a 1 per cent reduction in the total fuel used by all aircraft in the North Atlantic fleet. This equates to an annual saving of €108 million and a reduction of 344 000 tonnes of carbon dioxide emissions.

1.2.3 RTCA and European Organisation for Civil Aviation Equipment (EUROCAE) developed a concept of operations for ITP that included a coordinated determination of requirements and interoperability for early implementation of ADS-B applications. ITP safety performance and requirements are specified in RTCA DO-312 and in EUROCAE ED-159, *Safety Performance and Interoperability Requirements Document for the In-Trail Procedure in Oceanic Airspace (ATSA-ITP) Application* and its Supplement. Furthermore, additional guidance can be found in EUROCAE ED-194 and RTCA DO-317A, *Minimum Operational Performance Standards (MOPS) for Aircraft Surveillance Applications (ASA) System* and its Supplement.

1.3 PANS-ATM AMENDMENTS

1.3.1 In addition to establishing the ITP separation minimum from the collision risk model, ICAO has developed procedures and material described in the *Procedures for Air Navigation Services — Air Traffic Management* (PANS-ATM, Doc 4444).

Note.— At the time of writing these were awaiting approval and publication.

1.3.2 The ITP is described in detail in 5.4.2.7,* "longitudinal separation minima based on distance using ADS-B in-trail procedure (ITP)" in PANS-ATM. Appendix 5 contains the related controller-pilot data link communications (CPDLC) message set.

Chapter 2

DESCRIPTION OF THE ITP, MINIMA AND SYSTEM REQUIREMENTS

Note.— References followed by an asterisk (*) can be found in proposed Amendment 6 to the Procedures for Air Navigation Services — Air Traffic Management *(PANS-ATM, Doc 4444) (applicable November 2014).*

2.1 INTRODUCTION

2.1.1 This chapter provides a high-level overview of ITP and its separation minimum.

2.1.2 The proposed implementation of ITP in this circular is primarily intended to help facilitate access to optimum flight levels for aircraft operating in airspace where no ATS surveillance service is available. ITP would require the manoeuvring aircraft (hereafter referred to as the ITP aircraft) to acquire and process automatic dependent surveillance — broadcast (ADS-B) data from up to two non-manoeuvring aircraft (hereafter referred to as reference aircraft). Aircraft identification, altitude, position and ground speed of reference aircraft would be assessed by the ITP aircraft's on-board equipment (on-board decision support system) to determine whether an ITP climb or descent is possible. Based on the processed ADS-B data from the reference aircraft, a pilot can make an ITP climb or descent request to air traffic control (ATC). Pilots are responsible for using the on-board equipment to evaluate the situation and provide the required information to the controller. The controller maintains separation responsibility at all times between aircraft as dictated by the airspace class in which the operations occur.

2.1.3 Once the pilots have determined that the ITP criteria have been met, they may request an ITP climb or descent, identifying any reference aircraft in the clearance request. Controllers would receive the ITP clearance request and verify that the ITP aircraft and each reference aircraft are on the same track and the maximum closing Mach speed is not exceeded. This check is to account for potentially unsafe closure rates due to abnormal, adverse wind gradient conditions.

Note.— As described in 5.4.2.1.5 in the PANS-ATM, the same track would be same direction tracks and intersecting tracks or portions thereof, the angular difference of which is less than 45 degrees or more than 315 degrees, and whose protected airspaces overlap. (See Figure 2-1.)

2.1.4 System requirements

2.1.4.1 Solely having an ADS-B traffic display can provide improved situational awareness, but it is not sufficient for the ITP climb or descent. The ITP requires on-board ADS-B IN with additional on-board processing so that the ITP aircraft can determine whether the necessary criteria can be met and, if so, allow the pilot to request air traffic controller approval to execute the desired flight level change using the ITP separation minima between the reference aircraft.

2.1.4.2 The ITP equipment will verify the quality of the position data received from reference aircraft. In order to properly perform the ITP assessment and reassessment against the criteria, a minimum data set needs to be available, and specific data items and/or conditions need to be conveyed to the pilot. There is also a minimum level of performance requirements from the ITP equipment. Such requirements include the system's integrity, proficiency in performing calculations, conveying information to the pilot, latency and other timing requirements. These functional and performance requirements are specified in DO-312 and ED-159 and Supplement. The avionics standards for ITP are defined in DO-317A and Supplement and in ED-194.

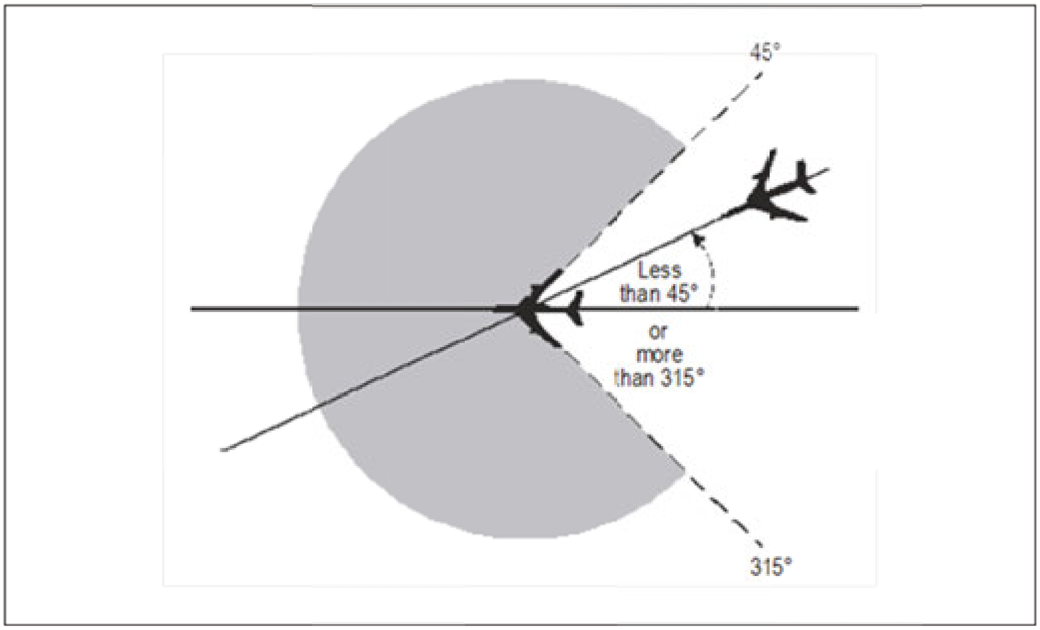


Figure 2-1. Aircraft on same track

2.1.4.3 It was determined that the safest way to exchange information and clearances between pilots and controllers was through CPDLC. CPDLC allowed for the reference aircraft call sign to be referred to by the ITP aircraft and the controller, without increasing the risk of confusion, compared to conventional radios (very high frequency (VHF) or high frequency (HF)). In addition, CPDLC provided the pilot with a "written" copy of the clearance which could be referred to just before or during the ITP climb or descent.

Note.— Satellite phone communications (SATCOM voice) have not been evaluated as a means of communications for ITP.

2.1.4.4 CPDLC messages have been developed for ITP (see 2.3.14 below). Bearing in mind the challenges and the costs related to the update of the aircraft message set, a series of standardized free text messages was developed. Until automation allows for the use of pre-formatted messages, ITP users will need to enter in standardized free text messages.

2.1.4.5 The introduction of standardized free text messages required an amendment to Annex 10 — *Aeronautical Telecommunications*, Volume II — *Communication Procedures* (including those with PANS status) and PANS-ATM.

2.2 SEPARATION MINIMUM

2.2.1 Aircraft operators choosing to equip for ITP would be able to take advantage of this procedure when operating in proximity to other aircraft equipped with ADS-B transmitters. In situations where the current separation criteria would make it impossible, ITP enables an aircraft on the same track to climb or descend to a requested flight level while crossing levels occupied by other aircraft. ITP criteria are designed such that two aircraft would rarely be closer than 19 km (10 NM) while vertical separation is not applied.

2.2.2 Potentially blocking aircraft may be from 1 000 to 2 000 ft above or below the ITP aircraft and the remaining levels may be occupied by other aircraft flying in the same or opposite direction to the ITP aircraft, or crossing the ITP aircraft's track. The controller ensures that standard separation is maintained between the ITP aircraft and all other aircraft not identified as a reference aircraft.

2.2.3 If the controller determines that standard separation minima will be met with all aircraft other than the ITP reference aircraft, a clearance for the climb or descent may be issued. The controller is required to check the reported ITP distance for consistency with the ITP criteria but does not determine or verify the accuracy of the reported ITP distance between the ITP aircraft and reference aircraft.

2.2.4 As described in 5.4.2.7.3.2 g)* in the PANS-ATM, the reference aircraft shall be non-manoeuvring and not expected to manoeuvre during the ITP. In this context, a manoeuvre would be a change of speed, flight level or direction. A change of course (only) by aircraft (ITP and reference aircraft) to remain on the same identical track would not be considered a manoeuvre. The application of strategic lateral offset procedures (SLOP) by pilots to mitigate against collisions or wake turbulence has been taken into account in the development of the procedure and determined not to conflict with this procedure. Similarly, with the exception of the ITP climb or descent, the ITP aircraft is not expected to manoeuvre during the ITP.

2.2.5 ITP distance

2.2.5.1 The ITP equipment calculates ITP distance, which is the absolute value of the distance between the ITP aircraft and the reference aircraft as defined by:

a) the difference in distance to an aircraft calculated common point along a projection of each other's track where aircraft are on the same track; or

b) the distance measured along the track of one of the aircraft using its calculated position and the point abeam the calculated position of the other aircraft where aircraft are on parallel tracks.

2.2.5.2 Figures 2-2 to 2-6[1] show ITP distance and how it is calculated for various traffic configurations. This measurement technique is similar to the method described in PANS-ATM, section 5.4.2.6.4.

2.2.5.3 In the case where aircraft are on parallel tracks, the ITP distance is measured along the track of one of the aircraft using its calculated position and the point abeam the calculated position of the other aircraft (see Figure 2-2). The common point can be an arbitrary point along one aircraft's track or the abeam point (i.e. in Figure 2-2, d2 can be equal to zero). The distance from each aircraft to the common point is a scalar quantity and is always positive (i.e. d1 and d2 are always positive scalar quantities).

2.2.5.4 For situations where aircraft are on opposite sides of the common point, note that the equation changes and the distances are additive.

2.2.5.5 In cases of converging or diverging intersecting tracks, when traffic meets the following criteria, the ITP aircraft marks the ITP similar track status (same track) as valid (see Figures 2-3, 2-4 and 2-5):

Similar track status (same track) is valid if the relative track angle between the ITP aircraft and any reference aircraft is less than 45 degrees or more than 315 degrees.

[1] *Figures 2-2 to 2-6 are copyrighted by RTCA MOPS and reproduced in this circular with their permission.*

Note.— As described in 5.4.2.1.5 in the PANS-ATM, the same track would be same direction tracks and intersecting tracks or portions thereof, the angular difference of which is less than 45 degrees or more than 315 degrees, and whose protected airspaces overlap.

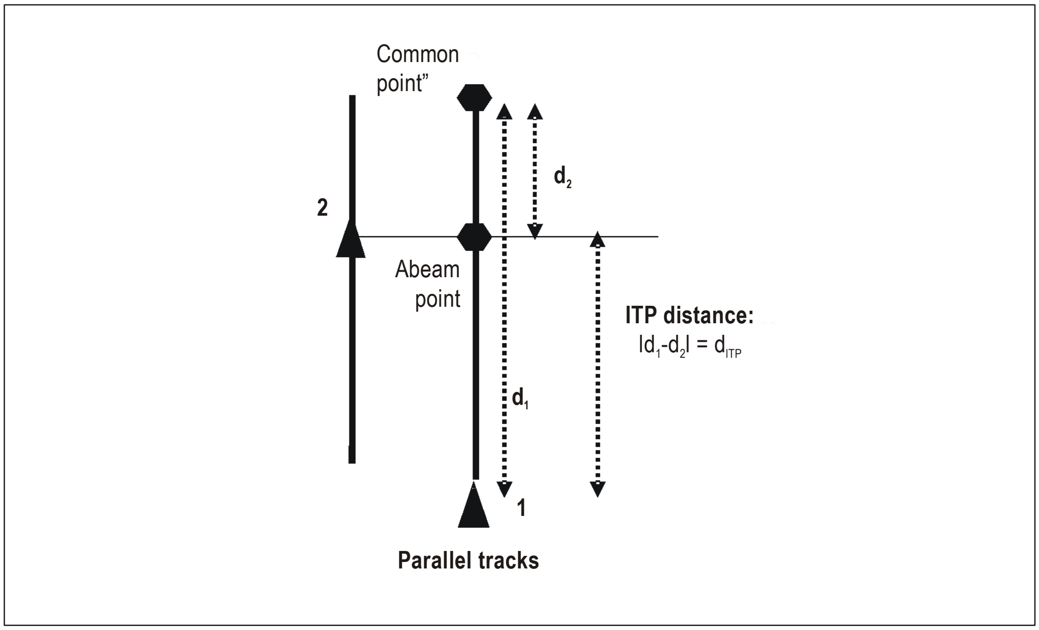


Figure 2-2. ITP distance for parallel tracks

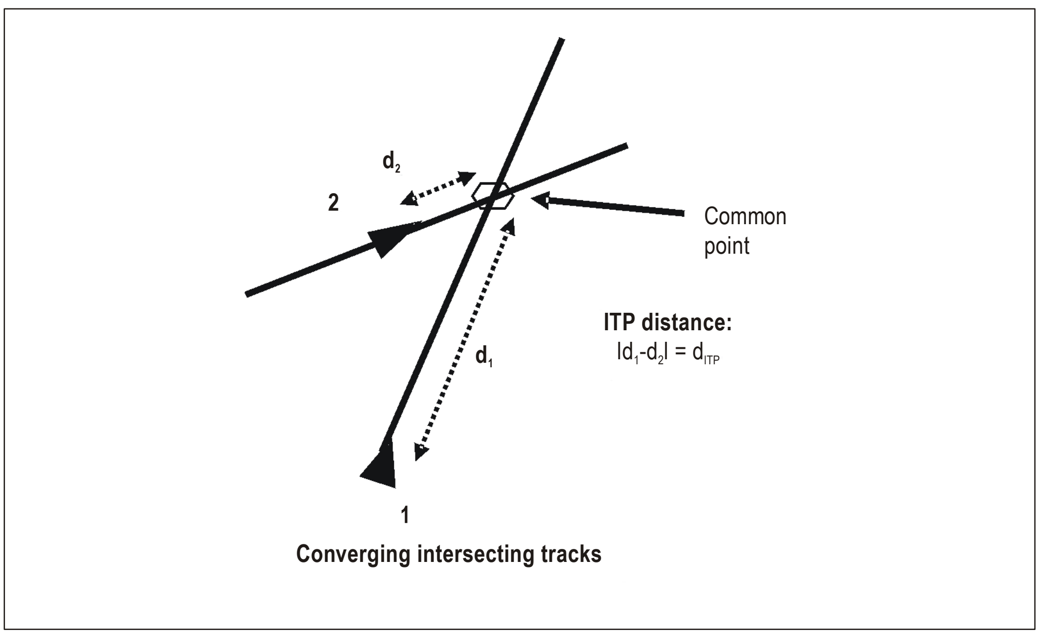


Figure 2-3. ITP distance for converging intersecting tracks

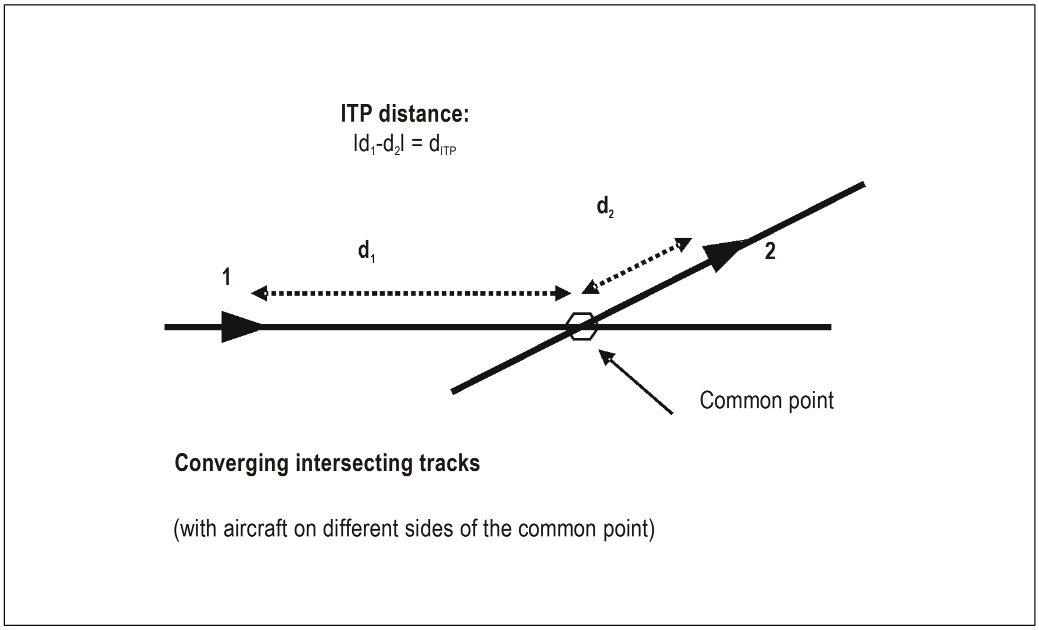


Figure 2-4. ITP distance for converging intersecting tracks

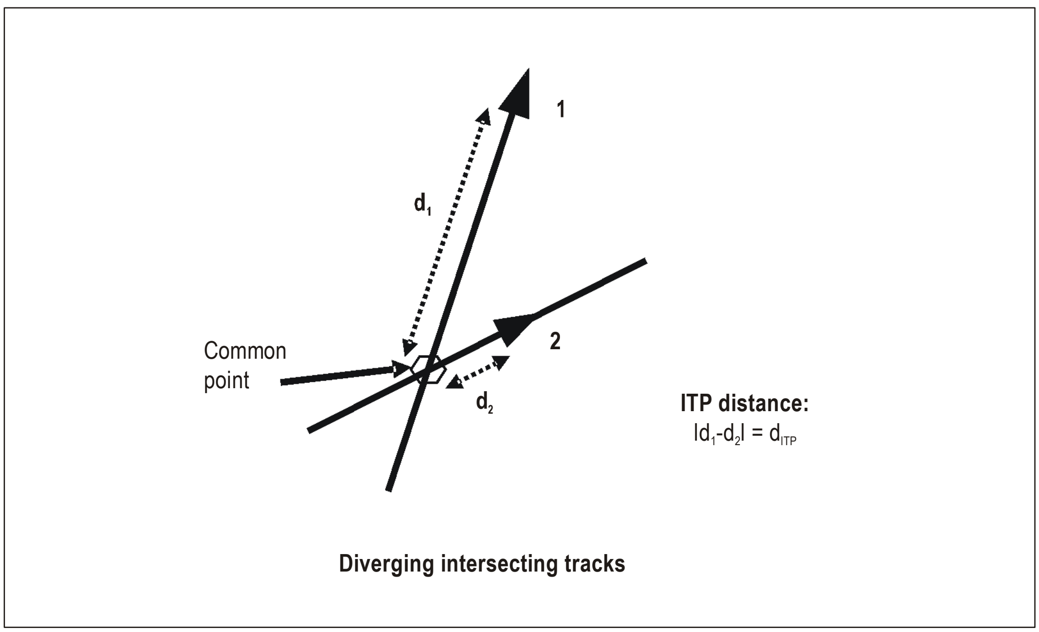


Figure 2-5. ITP distance for diverging intersecting tracks

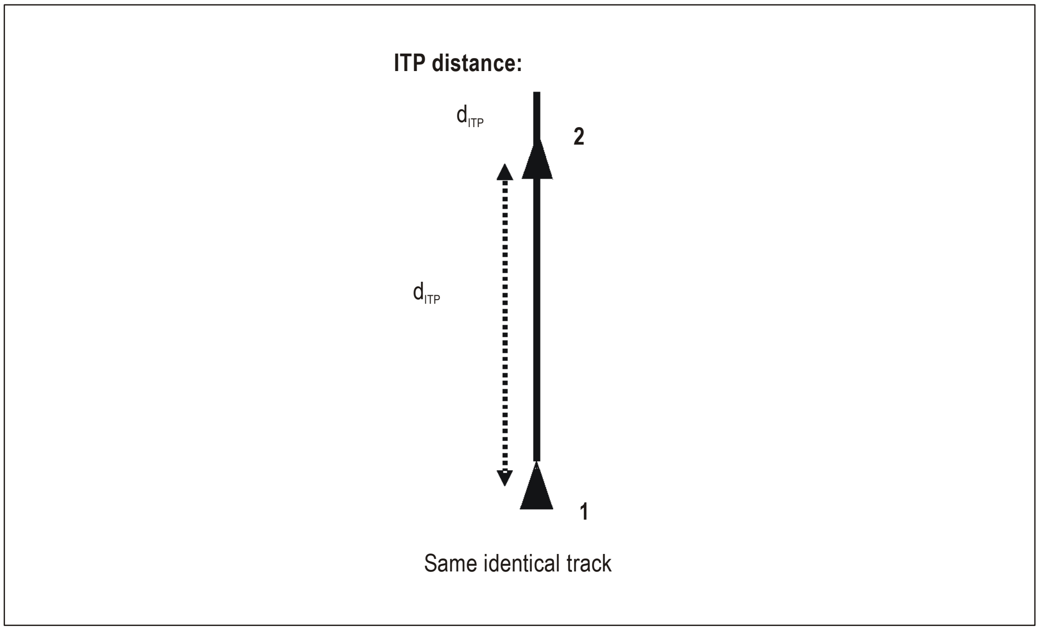


Figure 2-6. ITP distance for same identical track

2.3 DETAILED DESCRIPTION OF ITP

*Note.— This section contains supplemental information about ITP which can be used for reference purposes. However, for more details on ITP, refer to in PANS-ATM, 5.4.2.7.**

2.3.1 The ITP followed by the pilot and the controller is as follows.

2.3.1.1 Based on the ITP on-board equipment (on-board decision support systems) a pilot, appropriately qualified for ITP, determines that a flight level change is desirable and an ITP climb or descent is possible.

2.3.1.1.1 As described in 2.1.3, ITP aircraft will have approved ITP equipment which provides the pilot with the information necessary to assess and request an ITP. This information includes the flight ID and other information required to determine whether the ITP criteria are met (flight level, similar track status, ITP distance and closing ground speed) for potentially blocking aircraft with qualified ADS-B data.

2.3.1.2 Additionally, the ITP aircraft is required to have operations specifications (OpSpecs), an operations manual or other appropriate material, as required by State regulations to permit the use of the ITP.

2.3.2 The pilot reviews the information from the on-board equipment (on-board decision support systems) to determine whether the ITP criteria are met.

Note.— These criteria are specified in terms of ground speed and distance values which need to exist prior to initiating the ITP climb or descent.

2.3.3 An ITP climb or descent may be requested by the pilot provided the following ITP criteria are satisfied:

a) the ITP distance between the ITP aircraft and the reference aircraft shall be:

1) not less than 28 km (15 NM) with a maximum closing ground speed of 37 km/h (20 kt); or

2) not less than 37 km (20 NM) with a maximum closing ground speed of 56 km/h (30 kt);

b) the ITP on-board equipment shall indicate that the angle between the current tracks of the ITP aircraft and reference aircraft is less than 45 degrees;

c) the altitude difference between the ITP aircraft and any reference aircraft shall be 600 m (2 000 ft) or less;

d) the climb or descent shall be conducted at a rate of not less than 1.5 m/s (300 fpm) or any higher rate when specified by the controller; and

e) the climb or descent shall be performed at the assigned Mach number. If no Mach number has been assigned by ATC, the ITP aircraft shall maintain the current cruise Mach number throughout the ITP manoeuvre.

Note.— These criteria are designed to ensure a minimum separation of 19 km (10 NM) between the ITP aircraft and the reference aircraft during the climb or descent.

2.3.4 As described in 5.4.2.7.3* in the PANS-ATM, an ITP aircraft shall not be separated simultaneously from more than two reference aircraft using the ITP separation minimum.

2.3.5 The pilot of the ITP aircraft requests clearance from ATC to conduct the ITP climb or descent to the requested flight level. The request will include the aircraft identification of up to two reference aircraft (i.e. potentially blocking aircraft that meet the ITP criteria) and their ITP distance. As described in 5.4.2.7.2* of the PANS-ATM, this request shall be made using CPDLC.

2.3.6 The controller will assess the request using ITP criteria. A controller may clear an aircraft for an ITP climb or descent provided the following conditions are satisfied:

a) the ITP climb or descent has been requested by the pilot;

b) the aircraft identification of each reference aircraft in the ITP request exactly matches the Item 7 — aircraft identification of the corresponding aircraft's filed flight plan;

c) the reported ITP distance between the ITP aircraft and any reference aircraft is 28 km (15 NM) or more;

d) both the ITP aircraft and reference aircraft are either on:

1) same identical tracks and any turn at a waypoint shall be limited to less than 45 degrees; or

2) parallel tracks or same tracks with no turns permitted during the manoeuver.

Note.— Same identical tracks are a special case of same track as defined in 5.4.2.1.5 a) in the PANS-ATM where the angular difference is zero degrees.

e) no speed or route change clearance shall be issued to the ITP aircraft until the ITP climb or descent is completed;

f) the altitude difference between the ITP aircraft and any reference aircraft shall be 600 m (2 000 ft) or less;

g) no instructions to amend speed, altitude or route shall be issued to any reference aircraft until the ITP climb or descent is completed;

h) the maximum closing speed between the ITP aircraft and each reference aircraft shall be Mach 0.06; and

i) the ITP aircraft shall not be a reference aircraft in another ITP clearance.

Note 1.— The closing speed check is to account for potentially unsafe closure rates due to abnormal, adverse wind gradient conditions (e.g. tailwind or headwind changes dramatically during the flight level change). This check is verification that the co-altitude closure rate is reasonable with a reference aircraft. The closing speed check needs to be performed by the controller and not the pilot, because current ADS-B messages only include ground speed information.

Note 2.— A check for potential blocking aircraft not identified in the ITP clearance request needs to be performed.

2.3.7 As described in 2.3.6 g), the controller shall not issue any clearance to the reference aircraft that could affect the ITP criteria until the ITP aircraft is re-established with standard vertical separation against reference aircraft. ATC may inform the pilot once the ITP climb or descent is completed to resume normal climb or descent.

2.3.8 Following receipt of an ITP climb or descent clearance and before initiating the procedure, the pilot of the ITP aircraft shall determine that the ITP criteria referred to in 2.3.3 a) and b) are still being met with respect to the reference aircraft identified in the clearance and:

a) if the ITP criteria are satisfied, the pilot shall accept the clearance and commence the climb or descent immediately; or

b) if the ITP criteria are no longer satisfied, the pilot shall notify the controller and maintain the previously cleared level.

2.3.9 As described in 5.4.2.7.3.1* and 5.4.2.7.3.2* of the PANS-ATM, during ITP climb or descent, the ITP aircraft shall maintain a climb or descent rate of not less than 1.5 m/s (300 fpm) or any higher rate when specified by the controller.

2.3.10 After acceptance of the ITP clearance and initiation of the manoeuvre, the pilot is not required to monitor any information regarding the reference aircraft, such as range or ground speed difference.

2.3.11 While performing the ITP climb or descent, the pilot monitors the speed as well as the climb or descent rate. If the manoeuvre cannot be accomplished at the original cruise Mach and meet the minimum continuous climb or descent rate of 1.5 m/s (300 fpm), the ITP aircraft must notify the controller immediately and request an alternative clearance. If unable to obtain this clearance, the pilot shall follow the contingency procedures contained in Chapter 15, 15.2, of the PANS-ATM.

2.3.12 If the ITP cannot be successfully completed once the climb or descent has been initiated, the pilot should notify ATC and request an alternative clearance. If unable to obtain this clearance, the pilot shall follow the contingency procedures contained in Chapter 15, 15.2, of the PANS-ATM.

2.3.13 Examples of ITP climb and descent scenarios

2.3.13.1 *ITP behind climb.*

a) in Figure 2-7 the ITP aircraft is behind a reference aircraft which is at a higher intervening flight level (FL350). Standard ATC procedures apply to the other aircraft (two aircraft at FL360 and one at FL350); and

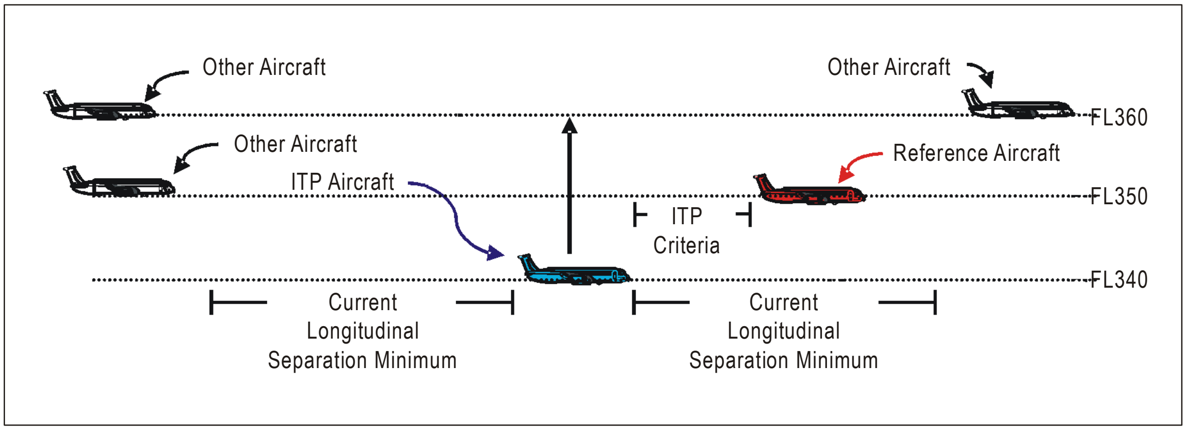


Figure 2-7. ITP behind climb

b) in Figure 2-8 the ITP aircraft is behind two reference aircraft which are at higher intervening flight levels, one aircraft at FL350 and one at FL360. The other aircraft (two at FL370 and one at FL350) are not specifically part of the ITP, and standard ATC procedures apply.

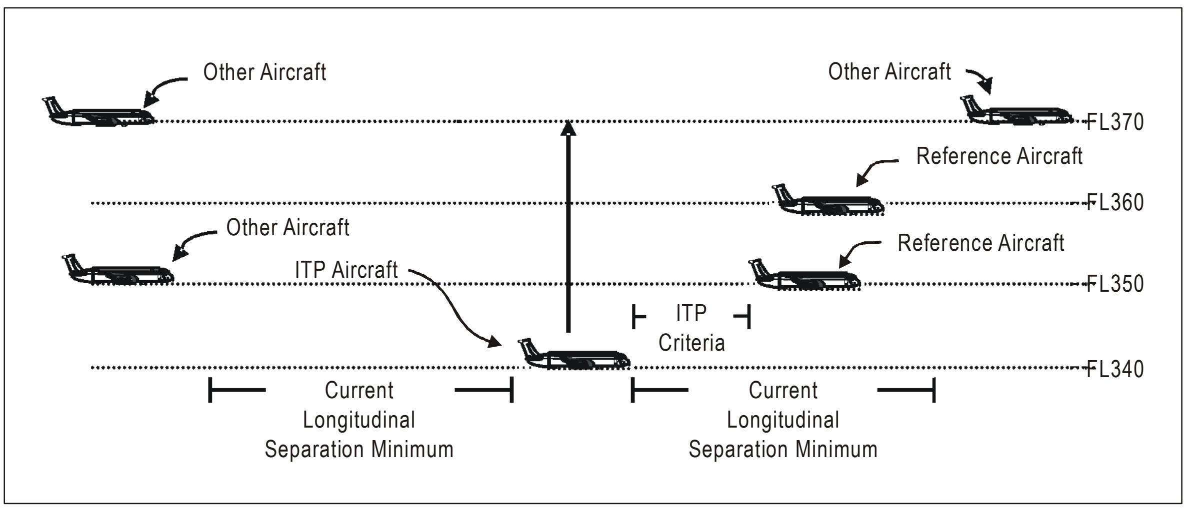


Figure 2-8. ITP behind climb with two reference aircraft

2.3.13.2 *ITP behind descent*. The ITP aircraft is behind a reference aircraft which is at a lower intervening flight level (see Figure 2-9).

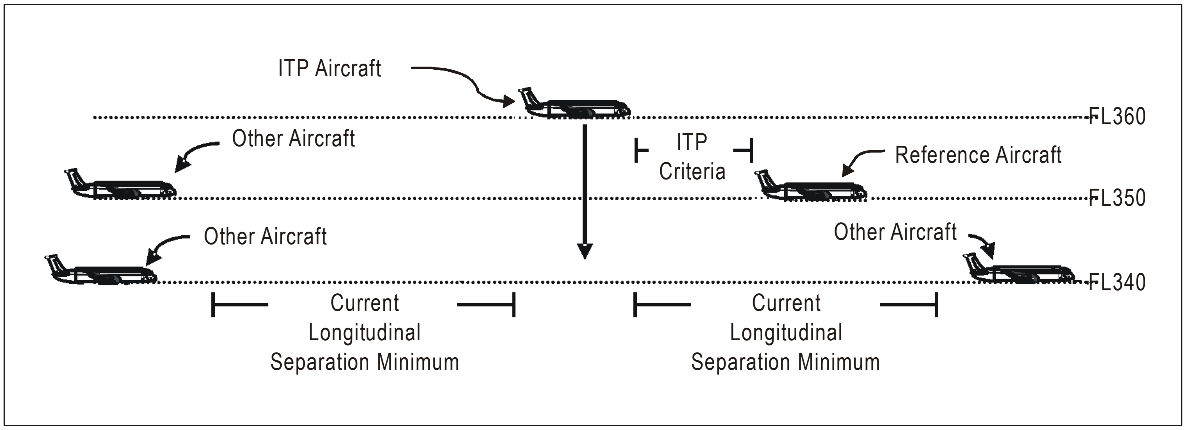


Figure 2-9. ITP behind descent

2.3.13.3 *ITP ahead of climb*. The ITP aircraft is ahead of a reference aircraft which is at a higher intervening flight level (see Figure 2-10).

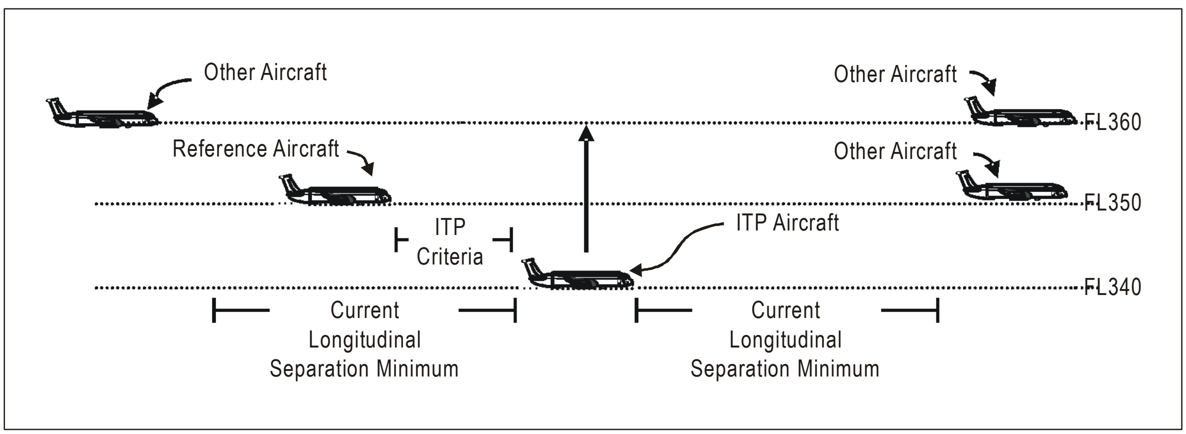


Figure 2-10. ITP ahead of climb

2.3.13.4 *ITP ahead of descent*. The ITP aircraft is ahead of a reference aircraft which is at a lower intervening flight level (see Figure 2-11).

2.3.13.5 *Combined ahead of-behind climb*. The ITP aircraft is ahead of one reference aircraft and behind another reference aircraft. Both reference aircraft may be at the same, higher intervening flight level (FL350) or at different intervening flight levels (FL350 and FL360) (see Figures 2-12 and 2-13).

2.3.13.6 *Combined ahead of-behind descent.* The ITP aircraft is ahead of one reference aircraft and behind another reference aircraft, where both reference aircraft are at lower intervening flight levels (FL350) (see Figure 2-14). Note that the combined ahead of-behind descent geometry may also have two intervening flight levels (similar to a combined ahead of-behind climb shown in Figure 2-13).

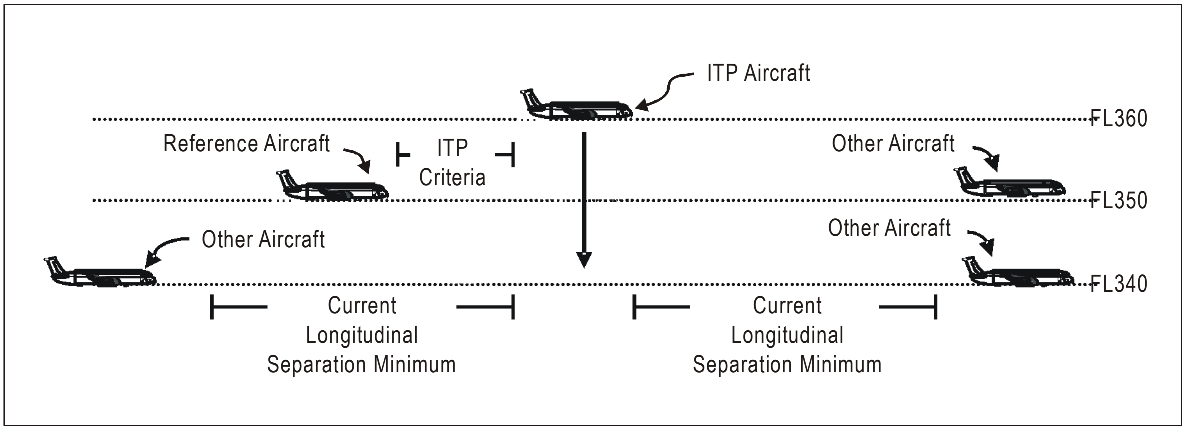


Figure 2-11. ITP ahead of descent

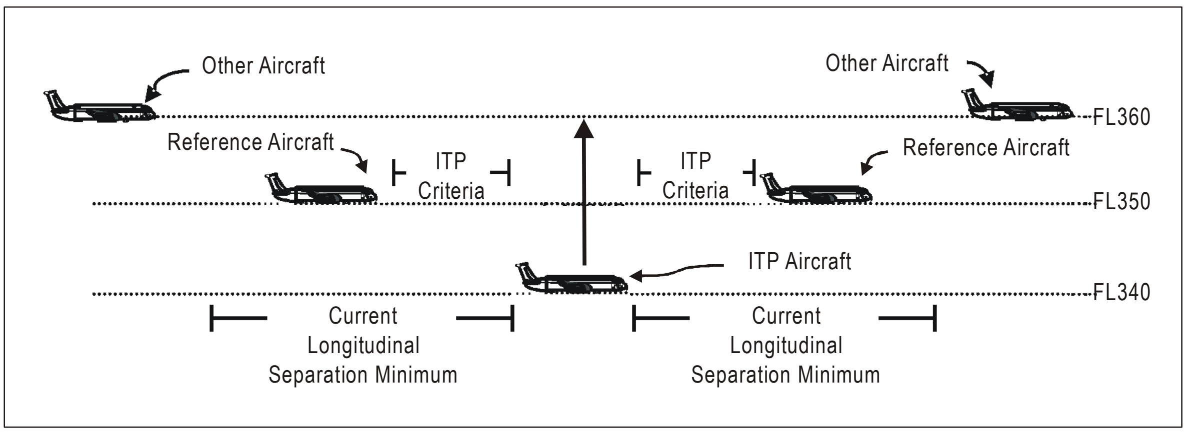


Figure 2-12. Example of a combined ahead of-behind climb with one intervening flight level

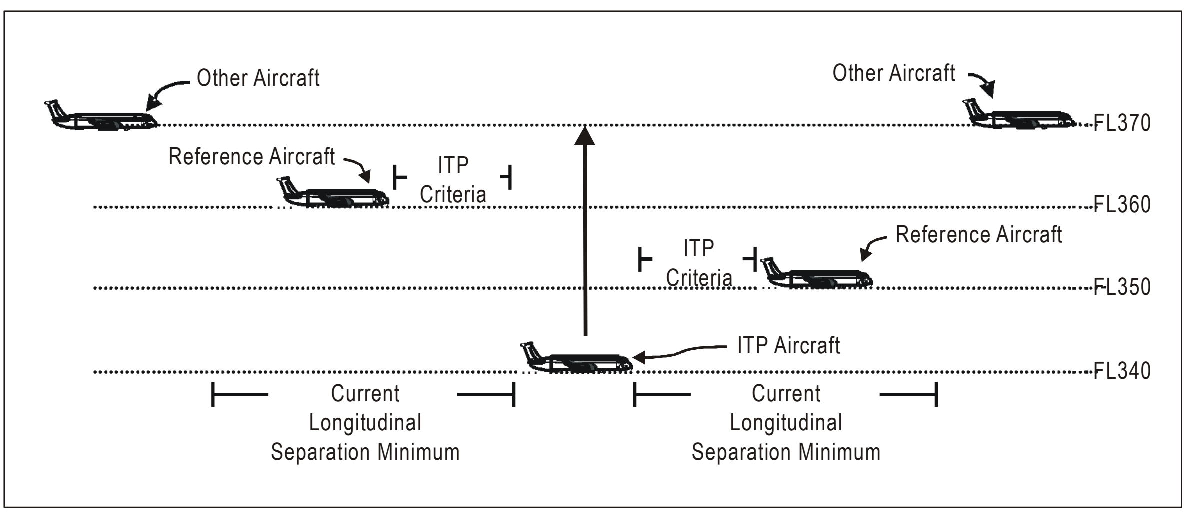


Figure 2-13. Example of a combined ahead of-behind climb with two intervening flight levels

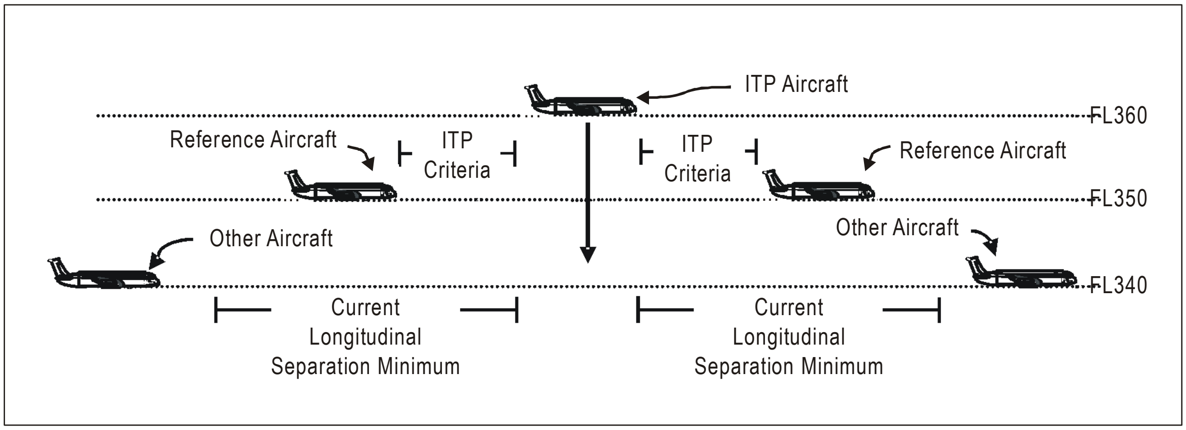


Figure 2-14. Example of a combined ahead of-behind descent

2.3.14 *CPDLC messages set*. As described in 2.3.5, ITP requests and clearances shall be communicated via a CPDLC message exchange only and in accordance with the appropriate message elements given in Appendix 5 of PANS-ATM. The format/content of CPDLC messages to support ITP are published in the PANS-ATM. These messages may be implemented as dedicated messages or composed as shown in the following paragraphs using a combination of standardized free text message elements and the standard message elements given in the CPDLC message set.

2.3.14.1 *Use of downlink CPDLC messages set*. As described in Table A5-24,* Spacing messages (downlink), of Appendix 5 in the PANS-ATM, the airborne system will append the vertical request message element with a free text message DM67. When a vertical request for climbing (or for descending) has been prepared as part of an ITP transaction, the aircraft shall send a downlink message containing DM9 REQUEST CLIMB TO [altitude] (resp. DM10 REQUEST DESCENT TO [altitude]) concatenated with message element DM67 containing the text described in Table 2-1.

Table 2-1. Message element DM67

ITP procedure type (number and relative position of reference aircraft)	*DM67 message element content*
1 reference aircraft (ahead)	ITP (distance) BEHIND (aircraft identification of reference aircraft)
1 reference aircraft (behind)	ITP (distance) AHEAD OF (aircraft identification of reference aircraft)
2 reference aircraft (both ahead)	ITP (distance) BEHIND (aircraft identification of reference aircraft) AND (distance) BEHIND (aircraft identification of reference aircraft)
2 reference aircraft (both behind)	ITP (distance) AHEAD OF (aircraft identification of reference aircraft) AND (distance) AHEAD OF (aircraft identification of reference aircraft)
2 reference aircraft (one ahead and one behind)	ITP (distance) BEHIND (aircraft identification of reference aircraft) AND (distance) AHEAD OF (aircraft identification of reference aircraft)

2.3.14.2 *Use of uplink CPDLC messages set*. As described in Table A5-12,* Spacing messages (uplink) of Appendix 5 in the PANS-ATM, the controller will append the vertical request message element with a free text message UM169. When a vertical clearance for climbing (or for descending) has been prepared as part of an ITP transaction, the ground system shall send an uplink message containing UM20 CLIMB TO AND MAINTAIN [altitude] (resp. UM23 DESCEND TO AND MAINTAIN [altitude]) concatenated with message element UM169 containing the text described in Table 2-2.

Note.— UM20 and UM23 may be replaced by UM26, UM27, UM28 and UM29 as appropriate. Message elements UM46, UM47 or UM48 may also be added after UM20 and UM23 (see Table 2-3).

Table 2-2. Message element UM169

ITP procedure type (number and relative position of reference aircraft)	*UM169 message element content*
1 reference aircraft (ahead)	ITP BEHIND (aircraft identification of reference aircraft)
1 reference aircraft (behind)	ITP AHEAD OF (aircraft identification of reference aircraft)
2 reference aircraft (both ahead)	ITP BEHIND (aircraft identification of reference aircraft) AND BEHIND (aircraft identification of reference aircraft)
2 reference aircraft (both behind)	ITP AHEAD OF (aircraft identification of reference aircraft) AND AHEAD OF (aircraft identification of reference aircraft)
2 reference aircraft (one ahead and one behind)	ITP BEHIND (aircraft identification of reference aircraft) AND AHEAD OF (aircraft identification of reference aircraft)

2.3.14.3 In ATC systems, UM169 should be provided as a pre-formatted free text message element when it is used to identify ITP reference aircraft. This method reduces the manual text entry, requiring the controller to only enter the reference aircraft identification. It is also recommended that advanced air traffic control systems automatically generate the ITP clearance based on the data received in the downlink ITP request. This method reduces the manual text entry required by the controller even further and therefore reduces the margin for error.

2.3.14.4 Examples of ITP geometries and CPDLC messages are included in Table 2-3.

2.3.14.5 An example of ITP request message is: REQUEST CLIMB TO FL360 ITP 25NM BEHIND SIA228 AND 21NM AHEAD OF AFR008.

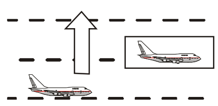
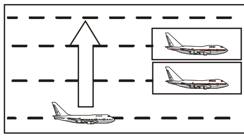
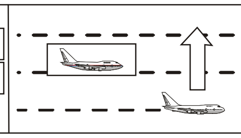
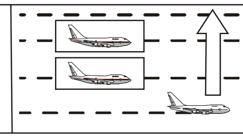
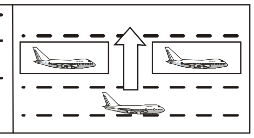
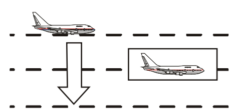
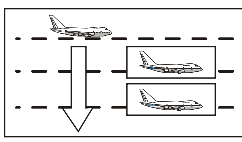
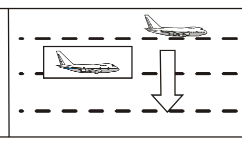
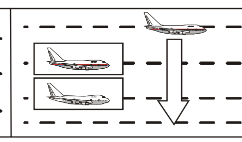
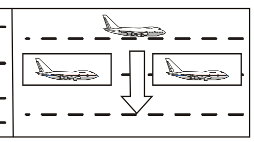
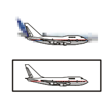
Note 1.— "Distance" is an integer value followed by NM and represents the ITP distance from the reference aircraft identified in the request.

Note 2.— "Aircraft identification" is defined in PANS-ATM, Item 7 of the flight plan (i.e. 2 to 7 characters).

2.3.14.6 An example of ITP clearance message is: ITP BEHIND SIA228 AND AHEAD OF AFR008 CLIMB TO FL360.

Note.— "Aircraft identification" is defined by PANS-ATM, Item 7 of the flight plan (i.e. 2 to 7 characters).

Table 2-3. Examples of ITP geometries and CPDLC messages

	ITP BEHIND manoeuvre		*ITP AHEAD of manoeuvre*		*ITP combined BEHIND and AHEAD of manoeuvre*
ITP CLIMB					
	PILOT request: DM9: REQUEST CLIMB TO [altitude] DM67: ITP [Distance] BEHIND [acid] ATC clearance: UM169: ITP BEHIND [acid] UM20: CLIMB TO AND MAINTAIN [altitude]	PILOT request: DM9: REQUEST CLIMB TO [altitude] DM67: ITP [Distance] BEHIND [acid1] AND [Distance] NM BEHIND [acid2] ATC clearance: UM169: ITP BEHIND [acid1] AND BEHIND [acid2] UM20: CLIMB TO AND MAINTAIN [altitude]	PILOT request: DM9: REQUEST CLIMB TO [altitude] DM67: ITP [Distance] AHEAD OF [acid] ATC clearance: UM169: ITP AHEAD OF [acid] UM20: CLIMB TO AND MAINTAIN [altitude]	PILOT request: DM9: REQUEST CLIMB TO [altitude] DM67: ITP [Distance] AHEAD OF [acid1] AND [Distance] AHEAD OF [acid2] ATC clearance: UM169: ITP AHEAD OF [acid1] AND AHEAD OF [acid2] UM20: CLIMB TO AND MAINTAIN [altitude]	PILOT request: DM9: REQUEST CLIMB TO [altitude] DM67: ITP [Distance] BEHIND [acid1] AND [Distance] AHEAD OF [acid2] ATC clearance: UM169: ITP BEHIND [acid1] AND AHEAD OF [acid2] UM20: CLIMB TO AND MAINTAIN [altitude]
ITP DESCENT					
	PILOT: DM10: REQUEST DESCENT TO [altitude] DM67: ITP [Distance] BEHIND [acid] ATC clearance: UM169: ITP BEHIND [acid] UM23: DESCEND TO AND MAINTAIN [altitude]	PILOT: DM10: REQUEST DESCENT TO [altitude] DM67: ITP [Distance] BEHIND [acid1] AND [Distance] BEHIND [acid2] ATC clearance: UM169: ITP BEHIND [acid1] AND BEHIND [acid2] UM23: DESCEND TO AND MAINTAIN [altitude]	PILOT request: DM10: REQUEST DESCENT TO [altitude] DM67: ITP [Distance] AHEAD OF [acid] ATC clearance: UM169: ITP AHEAD OF [acid] UM23: DESCEND TO AND MAINTAIN [altitude]	PILOT request: DM10: REQUEST DESCENT TO [altitude] DM67: ITP [Distance] AHEAD OF [acid1] and [Distance] AHEAD OF [acid2] ATC clearance: UM169: ITP AHEAD OF [acid2] AND AHEAD OF [acid2] UM23: DESCEND TO AND MAINTAIN [altitude]	PILOT request: DM10: REQUEST DESCENT TO [altitude] DM67: ITP [Distance] BEHIND [acid1] AND [Distance] AHEAD OF [acid2] ATC clearance: UM169: ITP BEHIND [acid1] AND AHEAD OF [acid2] UM23: DESCEND TO AND MAINTAIN [altitude]
	UM20 and UM23 may be substituted with: UM#26: CLIMB TO REACH [altitude] BY [time] UM#27: CLIMB TO REACH [altitude] BY [position] UM#28: DESCEND TO REACH [altitude] BY [time] UM#29: DESCEND TO REACH [altitude] BY [position]		The following elements may be added after UM20 and UM23: UM#46: CROSS [position] AT [altitude] UM#47: CROSS [position] AT OR ABOVE [altitude] UM#48: CROSS [position] AT OR BELOW [altitude]		

Chapter 3

SAFETY RISK ASSESSMENT

3.1 INTRODUCTION

This chapter summarizes the safety assessment performed to determine the ITP separation minimum. The methodology is explained below, as well as the rationale behind its use and the conclusions.

3.2 SCOPE

3.2.1 The safety assessment conducted to determine the ITP separation minimum was undertaken by ICAO for global application.

3.2.2 Within the scope of this safety assessment, it is necessary to distinguish between assessments undertaken by States for the purposes of implementation at the local level and those undertaken by ICAO from a global perspective. An assessment undertaken for global purposes does not always contain the information required to address specific local implementation requirements.

3.2.3 For example, because safety considerations are largely determined by the local operational environment, into which an international Standard is to be integrated, a full safety assessment should take into consideration the local operational environment. As such, airspace planners need to complement the ICAO assessment with a regional or local implementation-focussed 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 depicts the difference in the types of assessments.

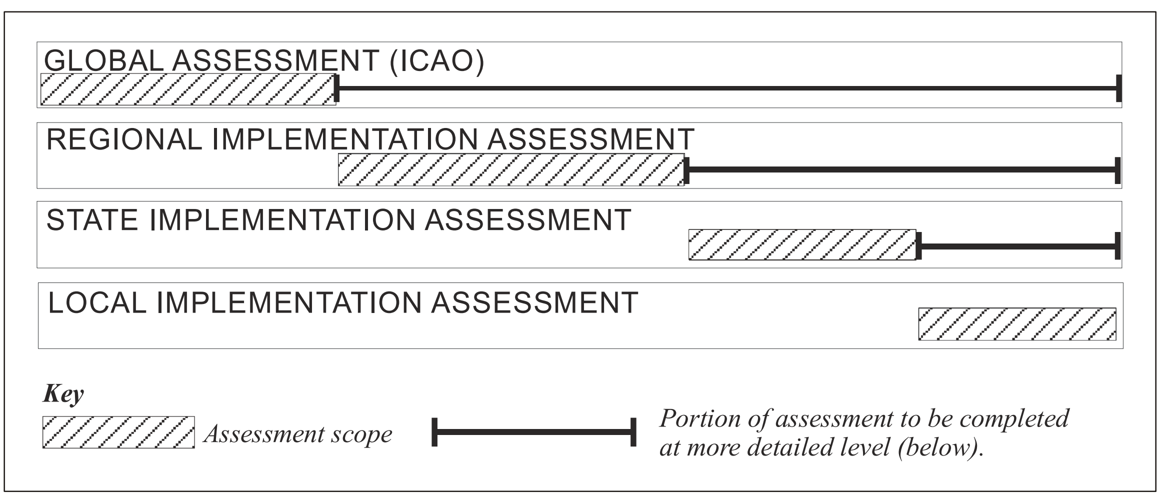


Figure 3-1. Difference in the scope of the assessment

3.2.4 As described in 2.6 of the PANS-ATM, a safety assessment shall be carried out in respect of proposals for significant airspace reorganizations, for significant changes in the provision of air traffic service (ATS) procedures applicable to an airspace or an aerodrome, and for the introduction of new equipment, systems or facilities. Since ITP will introduce a reduced separation minimum to be applied within an airspace, prior to the implementation, each State shall conduct its own safety assessments and analyse its local safety cases taking into account many risks which were outlined in the safety, performance and interoperability requirements in DO-312 and ED-159.

Note.— Although ICAO undertook a global assessment, States should note that ICAO's assessment is based on a number of assumed characteristics related to either the airspace environment or aircraft performance; therefore there are possibilities that ICAO was not able to assess all of the factors that might affect safety during State or Local implementations. These characteristics may not necessarily be the same as those relevant to any particular regional, State or local implementation.

3.3 OBJECTIVE OF THE ICAO SAFETY ASSESSMENT

The general objective of the ICAO assessment is to demonstrate that the ITP separation minimum of 19 km (10 NM) is safe for application, subject to an appropriate implementation safety assessment being undertaken.

3.4 ASSUMPTIONS

Several assumptions were made during the ICAO safety assessment. The prime assumption was that given the geometry of specific aircraft, and providing strict procedural criteria were met, an aircraft cleared for an ITP climb or descent could complete the manoeuvre without infringing on the ITP separation minimum until standard separation could be applied.

3.5 CONSTRAINTS AND ENABLERS

A significant enabler for ITP implementation is the development and equipping of aircraft with on-board ITP equipment. On the other hand, a significant constraint would be the percentage of aircraft equipped with compliant ADS-B out technology in any given airspace environment where ITP will be implemented.

3.6 DEVELOPMENT OF ICAO ASSESSMENT METHODOLOGY

3.6.1 For the development of the ITP separation minimum, the ICAO safety assessment was performed by the SASP Mathematical Sub-Group (MSG) using a collision risk model which was originally developed by RTCA and EUROCAE but included an additional two collision risk models.

3.6.2 Essentially the model calculates the probability of aircraft longitudinal overlap based on given values of accuracy for the global navigation satellite system (GNSS)/ADS-B, altitude error, latency error, initiation criteria parameters for the ITP, and a wind model. A parametric analysis was also performed to determine the sensitivity of collision risk to accuracy, integrity and initiation criteria.

3.6.3 In an effort to identify hazards that may affect the implementation and use of developed standards and to develop effective controls for these hazards, ICAO noted that a team of specialists comprised of pilots, air traffic controllers and engineers, undertook a process of hazard identification as part of the development of safety, performance and interoperability requirements documented in DO-312 and ED-159. The results of this activity are detailed in the appendix to this circular.

Note.— The hazards and controls identified in this document are the result of one hazard identification activity. Complementary regional, State or local implementation safety assessment action will still need to be undertaken.

3.7 CONCLUSIONS

3.7.1 The application of the ITP and the minimum detailed in this circular have been determined as meeting the target level of safety. ICAO also identified a number of hazards together with appropriate controls and mitigations (refer to the appendix to this circular).

3.7.2 Notwithstanding the above, there is a requirement for a region or State to undertake an implementation safety assessment. To assist regions and States with this activity, an implementation roadmap is provided in Chapter 4.

Chapter 4

IMPLEMENTATION ROADMAP

Note.— References followed by two asterisks (**) can be found in proposed Amendment 6 to the Procedures for Air Navigation Services — Aircraft Operations *(PANS-OPS, Doc 8168) (applicable November 2014).*

4.1 INTRODUCTION

4.1.1 The successful implementation of separation minimum is not possible at the regional, State or local level without the respective entity undertaking its own safety assessment in that area.

4.1.2 When undertaking this activity, reference should be made to the requirements detailed in Annex 19 — *Safety Management*, Annex 11 — *Air Traffic Services*, PANS-ATM (Chapter 2, section 2.6), and in the guidance material contained in the *Safety Management Manual (SMM)* (Doc 9859). Other provisions may also be contained in Annex 6 — *Operation of Aircraft*.

Note.— Safety, performance and interoperability requirements found in DO-312 and ED-159 and Supplement may be used as a reference to conduct safety assessments in detail for the implementation of ITP.

4.1.3 This chapter provides an overview of the minimum steps that ICAO considers necessary for a region or State to undertake a safety assessment.

4.2 IMPLEMENTATION CONSIDERATIONS

When undertaking a regional or State implementation, the following steps are provided as guidance. These steps are illustrated in Figure 4-1.

Step 1: Undertake widespread regional consultation with all possible stakeholders and other interested parties.

Note.— ICAO did not assess cross-border operations of the ITP. However, for safe operation of the ITP, regional coordination and agreement are recommended.

Step 2: Develop an airspace design concept or ensure that the proposed standard being implemented will fit the current airspace system and regional or state airspace planning strategy.

Note.— Airspace and procedure design should follow the principles laid down in Doc 8168 (PANS-OPS) and PANS-ATM.

Step 3: Review the ITP in this circular and its reference documents, noting specific assumptions, constraints, enablers and system performance requirements.

Step 4: Compare ITP assumptions, enablers and system performance requirements with the regional or State's operational environment, infrastructure and capability.

Step 5: If a region or State determines that its proposal for change complies with the requirements and system performance in this ITP circular and reference documents, then, as described in Annex 19, the State shall undertake safety management activities including formal hazard identification and analysis activities with identification of preventive controls and mitigating actions.

Note.— The Safety Management Manual (SMM) *(Doc 9859) provides guidance related to safety management activities.*

Step 6: If a State determines that its change proposal does not comply with the ITP requirements and system performance in this circular and reference documents, the State should:

a) consider trade-offs to achieve technical and safety performance which match the referenced material in Step 3; or

b) conduct appropriate quantitative or qualitative risk analysis for the development of mitigating measures if needed.

Step 7: Develop suitable safety assessment documentation that contains hazard descriptions, the related consequences, the assessed likelihood and severity of the safety risks, and required safety risk controls.

Step 8: Develop an ANSP operational implementation plan to:

a) identify training and operational approval requirements;

b) develop ITP procedures and incorporate them into air traffic controller training and documentation;

c) establish air traffic controller recurrent training requirements;

d) develop and train ITP specific contingency procedures based on section 15.2 of PANS-ATM for the State or region, where necessary;

e) ensure data link messages are available in the ATM system as per Annex 10, Volume II;

f) plan and conduct an operational trial with operator(s) under appropriate conditions with clearly identified success/failure criteria;

g) review and evaluate operational trial results;

h) develop suitable post-implementation monitoring and review processes;

i) ensure transition to full implementation; and

j) promulgate State aeronautical information service (AIS) publications. Individual publications, procedures, implementation and timelines could be harmonized where these form part of a regional implementation plan.

Step 9: Regulatory requirements for aircraft operators. As described in 1.2.3,** PANS-OPS, Volume I, Part III, Section 7, operators shall include in their standard operating procedures (SOPs) (see Part III, Section 5, Chapter 1) specific guidance for using ADS-B IN to support ATC procedures specified in PANS-ATM.

Note.— Operators need to ensure that their personnel (pilots and dispatchers) are trained to operate ITP.

Recognizing the additional training and procedural requirements described in this circular and the certification and airworthiness provisions for the manoeuvring aircraft, States should also consider the following:

a) *operator's training programme*. guidance material will clearly detail the required and recommended training items to be included in an aircraft operator's training programme. These training items will in turn form the basis of any aircraft operator's approval. As described in 1.1.2,** PANS-OPS, Volume I, Part III, Section 7, training on the use of the ADS-B IN traffic display shall be provided to pilots. The aircraft operator's training programmes should support the following knowledge objectives. Each pilot member (pilot flying (PF) and pilot not flying (PNF)) should:

   1) understand the ADS-B ITP system, related components and operation, and failure conditions;

   2) understand the ITP initiation criteria that make an ITP climb/descent possible;

   3) understand the concept of ITP distance;

   4) know procedures for requesting an ITP clearance and actions to take when an ITP clearance cannot be complied with;

   5) know where to reference CPDLC message sets for ITP. If ITP messages are not incorporated into the CPDLC message set, know the essential elements of an ITP request and clearance;

   6) understand all display symbols for the installed ITP equipment;

   7) understand minimum climb/descent rates required in a fixed Mach environment;

   8) understand the need to verify that the ITP initiation criteria are still met once the clearance is received;

   9) know the contingency procedures to follow in the event that the ITP climb or descent must be discontinued, once climb/descent has been initiated; and

   10) know that if an ACAS resolution advisory (RA) occurs with a concurrent ITP clearance; follow the climb or decent in the ACAS RA command.

b) *airworthiness compliance*. The State needs to promulgate the acceptable means of compliance with regard to the airworthiness requirements. ADS-B ITP implementations may be hosted on various avionics platforms.

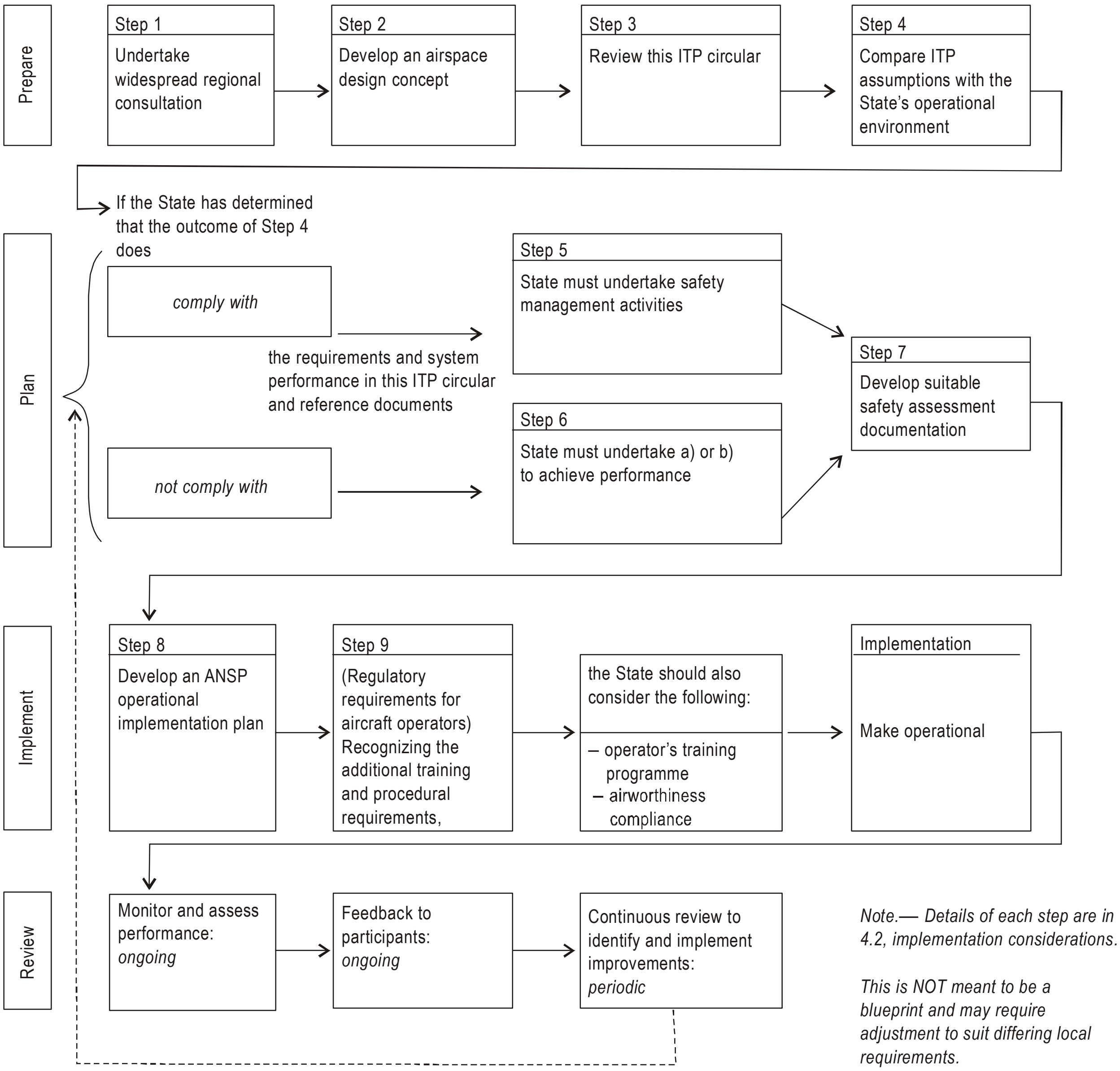


Figure 4-1. ITP implementation roadmap

Appendix

IMPLEMENTATION HAZARD LOG

1. Table App-1 lists the operational hazards that were considered by ICAO when developing the in-trail procedure (ITP) in this circular. Detailed information relating to the analysis of these hazards, including controls and mitigations, is provided in Annex C, Operational Safety Assessment, of DO-312 and ED-159, the *Safety, Performance and Interoperability Requirements Document for ATSA-ITP Application*.

Note.— In order to assess the severity of the various operational hazards that can affect the ITP application, documents DO-312 and ED-159 describe an expert operational analysis conducted with air traffic controllers and pilots. Six hazards were identified. Of these, operational hazards 1, 2 and 6 were analysed and categorized with a severity level of 4 (significant incidents). Hazards 3, 4 and 5 had no immediate effect on safety. Therefore, no safety objective was allocated and no safety requirement was derived for any of the latter three operational hazards.

2. As described in 2.6.1 of PANS-ATM, a safety assessment shall be carried out in respect of all proposals for significant airspace reorganizations. Since ITP will introduce a reduced separation minimum to be applied within an airspace, States and service providers need to consider, in their implementation safety assessment, the effect of these issues in their local implementation and additionally consider whether there are other regional or local issues that need to be considered (refer to Chapter 3).

Table App-1. Operational hazards in developing ITP

Operational hazard	*Description*
1	Interruption of an ITP manoeuvre. Interruption that prevents successful completion of ITP. Pilot abandons the manoeuvre. (Conditions external to the application such as an aircraft system failure or because of unintentional misuse of ITP equipment during an ITP manoeuvre requires the pilot to abandon the manoeuvre and follow regional contingency procedures.)
2	Execution of an ITP clearance not compliant with ITP criteria.
3	ITP request not accepted by ATC. (Pilot requests ITP, but the request is denied by ATC.)
4	Rejection by the pilot of an ITP clearance not compliant with the ITP criteria.
5	Rejection by the pilot of an ITP clearance compliant with the ITP criteria.
6	Incorrect execution of an ITP manoeuvre. (Incorrect execution of an ITP manoeuvre by the pilot by levelling off at the wrong flight level or delaying the initiation of the ITP climb/descent.)

— END —

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