

Directorate of Airspace Policy



CAP 778

**Policy and Guidance for the Design and
Operation of Departure Procedures in UK
Airspace**

www.caa.co.uk

CAP 778

Policy and Guidance for the Design and Operation of Departure Procedures in UK Airspace

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Revision History

Issue 1

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1 November 2012

Implementation of omnidirectional departures in the UK.

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Foreword

- 1** The Civil Aviation Authority's (CAA's) Directorate of Airspace Policy (DAP) is required, under Directions from the Secretary of State for Transport, to ensure that UK airspace is planned, provided and operated so as to ensure the safe and efficient operation of aircraft. In doing so, it is required to take into account the need to mitigate as far as possible the environmental impact of civil aircraft operations and in particular the disturbance to the public from aircraft noise, vibration and pollution. DAP's remit includes regulation of the development and application of notified departure procedures for UK aerodromes, and guidance on the establishment of Noise Preferential Routes (NPRs).
- 2** Within the UK, a SID provides a specified Instrument Flight Rules (IFR) departure procedure that remains wholly within Controlled Airspace (CAS) and permits connectivity with the en-route Air Traffic Service (ATS) route system. The International Civil Aviation Organisation (ICAO) uses the term SID and Standard Departure Route (SDR) to identify IFR departure procedures in general¹.
- 3** Certain UK aerodromes use the terms SDR, Preferred Departure Route (PDR) or Planned Departure Route (also PDR) to define IFR departure procedures that leave or remain outside CAS and have no direct connectivity to the en-route ATS system. However, misinterpretation of these terms and inconsistency in their application has led to confusion as to the purpose and status of such procedures. Therefore, it is the CAA's intention to progressively seek the removal of all references to each term in order to remove such confusion.
- 4** ICAO *PANS-OPS* sets the criteria by which SIDs are designed. The criteria are considered to be conservative in nature and do not necessarily reflect the performance capabilities of contemporary aircraft types². Therefore, in order to better reflect current aircraft performance and to satisfy specific UK operational and environmental circumstances, additional criteria for use in UK procedure design are considered necessary.
- 5** This document is to be used by those responsible for departure procedure design – principally specialist procedure designers – and also ATS and aerodrome operations staff. It sets out additional national requirements against which procedure designs submitted by procedure sponsors will be assessed and details how departure procedure design requirements are applied in the UK. The objective is to establish a uniform application of design parameters that will satisfy airspace safety requirements, provide maximum airspace capacity consistent with both safety and environmental requirements, and which will also be compatible with future Area Navigation (RNAV) procedure design requirements in terminal airspace.
- 6** In accordance with the principles of the European Civil Aviation Conference's (ECAC) strategic requirements, it is expected that RNAV procedures will become mandatory throughout European terminal airspace in the future. This document outlines the emerging requirements as they currently stand; however, it is recognised that these may be subject to change (both in content and timescale) as RNAV procedure design requirements evolve. Such changes will be reflected in future editions of this publication.

1. See ICAO *Annex 11 Air Traffic Services* and ICAO *Doc 8168 PANS-OPS Procedures for Air Navigation Services – Aircraft Operations*.
2. CAA SIDs and STARs Working Group WP1-99 'Aircraft Performance'.

- 7** As RNAV procedures are introduced into UK terminal airspace, it is recognised that existing procedures must be adapted to meet the more stringent procedure design requirements for RNAV systems. In many cases, existing conventional procedures may not be compatible with the detailed requirements of RNAV procedure design and aircraft Flight Management Systems (FMSs). In such cases it may be necessary for departure procedure profiles to be considered as airspace changes, and introduced in accordance with the Airspace Change Process¹.
- 8** **It is not intended to apply the requirements contained within this document retrospectively to existing conventional departure procedures.** However, procedure sponsors are expected to frequently review the design and application of their procedures to ensure that they satisfy changing safety, operational and environmental requirements. Should changing circumstances warrant changes in procedures, any such amendments shall be made in accordance with the requirements set out in this document.
- 9** The procedure design and consultation requirements outlined in this document are consistent with the requirements specified in DAP's Airspace Charter² for changes to airspace arrangements.

1. See CAP 724 Airspace Charter, Appendix F.

2. CAP 724 Airspace Charter. See also CAP 725 CAA Guidance on the Application of the Airspace Change Process.

Glossary

5LNC	Five-Letter Name Code
aal	Above Aerodrome Level
ACC	Area Control Centre
ACP	Airspace Change Proposal
AIP	Aeronautical Information Publication
amsl	Above Mean Sea Level
AOB	Angle of Bank
ARINC	Aeronautical Radio Incorporated (now known as ARINC)
ATC	Air Traffic Control
ATM	Air Traffic Management
ATS	Air Traffic Service(s)
ATT	Along Track Tolerance
AW	Area Width
B-RNAV	Basic RNAV
CA	Course to an Altitude
CAA	Civil Aviation Authority
CAP	Civil Aviation Publication
CAS	Controlled Airspace
CF	Course to a Fix
CTR	Control Zone
DAP	Directorate Of Airspace Policy
DER	Departure End of Runway
DF	Computed Track Direct To a Fix
DfT	Department for Transport (successor to the Department of the Environment, Transport and the Regions (DETR), the Department of Transport, Local Government and the Regions (DTLR) and the Department of Transport (DoT))
DME	Distance Measuring Equipment
DOC	Declared Operational Coverage
DR	Dead Reckoning
EASA	European Aviation Safety Agency
ECAC	European Civil Aviation Conference
EGxx	Generic reference to UK ICAO location indicators
EUROCAE	European Organisation for Civil Aviation Equipment
FA	Course from a Fix to an Altitude
FM	Course from a Fix to a Manual Termination

ft	feet
FTA	Fix Tolerance Area
GNSS	Global Navigation Satellite System
HA	Holding/Racetrack to an Altitude
IAS	Indicated Airspeed
ICAO	International Civil Aviation Organisation
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IMAL	Integrity Monitoring Alarm Limit
IRS	Inertial Reference System
IRU	Inertial Referencing Unit
ISA	International Standard Atmosphere
JAA	Joint Aviation Authorities
JAR	Joint Aviation Requirements
KIAS	Knots Indicated Airspeed
km	kilometre(s)
kt	knot(s)
Lat	Latitude
Long	Longitude
m	metre(s)
MagVar	Magnetic Variation
MAPt	Missed Approach Point
MASPS	Minimum Aircraft System Performance Standards
MATS	Manual of Air Traffic Services
MLS	Microwave Landing System
MOC	Minimum Obstacle Clearance
MTWA	Maximum Total Weight Authorised
NATMAC	National Air Traffic Management Advisory Committee
NATS	NATS Ltd (formerly National Air Traffic Services)
NDB	Non-Directional Beacon
NM	Nautical Mile(s)
NPR	Noise Preferential Route
OIS	Obstacle Identification Surface
PANS-OPS	Procedures for Air Navigation Services - Aircraft Operations
PBN	Performance Based Navigation
PDG	Procedure Design Gradient
PDR	Preferred Departure Route or Planned Departure Route

P-RNAV	Precision Area Navigation
RF	Constant Radius Arc to Fix (RNAV Path Terminator often referred to as "Fixed Radius Turn")
RNAV	Area Navigation
RNP	Required Navigational Performance
RSS	Root Sum Square
RT and RTF	Radiotelephony
RTCA	Radio Technical Commission for Aeronautics
SDR	Standard Departure Route
SID	Standard Instrument Departure
STAR	Standard Instrument Arrival Route
SVFR	Special Visual Flight Rules
TAS	True Airspeed
TF	Track to a Fix
TMA	Terminal Control Area
TORA	Take-Off Run Available
TOWP	Take-Off Waypoint
UK	United Kingdom
VA	Heading to an Altitude
VFR	Visual Flight Rules
VHF	Very High Frequency
VI	Heading to Intercept
VM	Heading to a Manual Termination
VOR	VHF Omnidirectional Range
XTT	Across Track Tolerance

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Chapter 1 Introduction

1 General Principles

- 1.1 The need for specific departure procedures is normally predicated on the location of an aerodrome and the types of aircraft and flights operating from it. General flying rules may require designated circuit directions and departure and joining procedures to enable the safe and efficient management of flights around the aerodrome itself. Additionally, the local terrain surrounding an aerodrome will often dictate the flight paths to be flown, particularly for Instrument Flight Rules (IFR) aircraft that cannot necessarily use visual guidance to avoid obstacles. Wherever departure procedures are introduced, they should be designed to accommodate all aircraft categories where possible.
- 1.2 Where Controlled Airspace (CAS) is established around an aerodrome, specific procedures may be required to exit a Control Zone (CTR) and also to assist Air Traffic Service (ATS) and aircrew planning. These procedures may include specific routes that IFR aircraft must follow to leave CAS or to enable connectivity, directly or otherwise, to the en-route ATS system. Additionally, specific entry and exit lanes may be established to facilitate the departure of Visual Flight Rules (VFR) and Special VFR (SVFR) flights.
- 1.3 The International Civil Aviation Organisation (ICAO) uses the term 'Standard Departure Routes' (SDRs) to refer to IFR departure routes in general¹. Certain UK aerodromes use either this term or 'Preferred Departure Route' or 'Planned Departure Route' (both PDR) to define IFR departure procedures that leave, or remain outside, CAS and have no direct connectivity to the en-route ATS system. However, misinterpretation of each of these terms and inconsistency in their application has led to confusion as to the purpose and application of such procedures. Therefore, it is the Civil Aviation Authority's (CAA's) intention to progressively remove all references to both terms in order to remove such confusion. Within the UK, the term **Standard Instrument Departure** (SID) is the sole term to be used in the context of routes providing designated IFR departure procedures that remain wholly within CAS and permit direct connectivity with the en-route ATS system.
- 1.4 In many cases, the environmental impact of the aerodrome operations may require specific flight paths to be followed to minimise the noise nuisance over the surrounding areas. These noise abatement procedures may require the establishment of **Noise Preferential Routes** (NPRs) and are generally applied to all aircraft departures that have a Maximum Total Weight Authorised (MTWA) of 5,700 kg or more, although certain other aircraft may be specifically exempted. The application of NPRs is described in Chapter 6².
- 1.5 **Where SIDs are established, their design will incorporate noise abatement requirements, e.g. promulgated NPRs.**
- 1.6 The processes for the design and application of SIDs and specific procedure design requirements are described elsewhere in this document.

1. See ICAO *Annex 11 Air Traffic Services* and ICAO *Doc 8168 PANS-OPS Procedures for Air Navigation Services – Aircraft Operations*.
2. See ICAO *Doc 8168 PANS-OPS Volume I, Part I, Section 7* for noise abatement considerations.

2 Basic Considerations¹

- 2.1 Departure procedures designed in accordance with ICAO *Doc 8168 PANS-OPS* and additional requirements contained within this document provide obstacle clearance immediately after take-off until the aircraft enters the en-route phase of flight.
- 2.2 A departure procedure may also be required for air traffic control, airspace management or other reasons (e.g. noise abatement) and the departure route or procedure may not be determined by obstacle clearance requirements alone. Departure procedures must be developed in consultation with aircraft operators, ATS providers and other parties concerned.
- 2.3 In the interest of efficiency and economy, every effort should be made to ensure that procedures are designed to minimise both the time taken in executing a departure and the volume of airspace required to contain them. However, the safety of operations is always the paramount consideration.

3 IFR Departure Procedures

- 3.1 The design of an instrument departure procedure is, in the first instance, dictated by the terrain surrounding the aerodrome, but may also be required to accommodate specific ATS requirements. These factors may, in turn, influence the type and siting of critical navigation aids in relation to the departure route in order for the procedure to be safely and efficiently flown. Additionally, the procedure design will need to take into account any airspace constraints and the location of available navigation aids, both of which may also affect the route to be flown.
- 3.2 At many aerodromes, a prescribed departure route is not required for ATC purposes. Nevertheless, there may be obstacles in the vicinity of an aerodrome that will have to be considered in determining whether restrictions to departures are to be prescribed. In such cases, departure procedures may be restricted to a given sector or may be published with a procedure design gradient in the sector containing the obstacle.
- 3.3 PANS-OPS criteria for omnidirectional departures are not currently applied in the UK. Consequently, omnidirectional departure procedures are not published in the *UK Aeronautical Information Publication (AIP)*.
- 3.4 Area Navigation (RNAV) procedures, including Precision RNAV (P-RNAV) in terminal airspace will be dependent to varying degrees on the availability and siting of critical Distance Measuring Equipment (DME) installations to enable the departure procedures to be flown. The process for the design and application of P-RNAV departure procedures is described in Chapter 5 of this document.

4 Application of CAP 778 Requirements

- 4.1 **The requirements of this document are not intended to be applied to existing 'legacy' procedures as part of any regularization exercise. Rather, they are intended to apply to new or replacement procedures.**

5 References

- 5.1 Source and reference documents are listed at Appendix A.

1. See ICAO *Doc 8168 PANS-OPS Volume II*, Section 3, Chapter 1.

Chapter 2 Omnidirectional Departures

1 Purpose of an Omnidirectional Departure

- 1.1 An omnidirectional departure is a convenient and simple method of ensuring obstacle clearance for IFR departing aircraft. At many aerodromes, a departure route is not required for ATC purposes or to avoid particular obstacles, however, there may be obstacles in the vicinity of an aerodrome which could affect IFR departures.

2 Omnidirectional Departures Design Principles

- 2.1 An omnidirectional departure procedure is designed on the basis that an aircraft maintains runway direction to a minimum height of 500 ft above aerodrome level before commencing a turn. The 500ft is a UK safety requirement and supersedes the ICAO minimum permissible turn height of 394 ft unless required for obstacle avoidance.¹
- 2.2 Where additional height is required for obstacle clearance the straight departure is continued until reaching the required turn altitude/height or a procedure design gradient (PDG) in excess of the standard 3.3% is promulgated.
- 2.3 On reaching the specified turn altitude/height a turn in any direction may be made to join the en-route phase of flight.
- 2.4 An omnidirectional departure may specify sectors with altitude or PDG limitations or sectors to be avoided.
- 2.5 Where an omnidirectional departure has a restriction, e.g. a PDG in excess of 3.3%, then an aerodrome is responsible for reflecting this restriction in any other departure procedure at that aerodrome.

3 Promulgation

- 3.1 Omnidirectional departures shall be promulgated in the UK IAIP Part 3 AERODROMES (AD) AD 2.22 in accordance with the following example:

Table 1

OMNIDIRECTIONAL DEPARTURES		
	Description	Restriction
RWY 05	Climb straight ahead MAG track 051° to 1500ft then turn on track climbing to enroute safety altitude/ MSA. PDG 3.3%	Sector anticlockwise 050° to 230° No Turns LEFT to North of runway below 2000ft
RWY 23	Climb straight ahead MAG track 231° to 1700ft then turn on track climbing to enroute safety altitude/ MSA.	PDG 4.5% to 1700ft then 3.3% after the turn
RCF	If different from standard procedures	

1. The UK Safety Requirement originates from a CAA Report into the Safety Aspects of Terminal Area Procedures, with particular reference to Noise Abatement, June 1974 (commissioned consequent to a Public Inquiry into an aircraft accident).

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Chapter 3 Standard Instrument Departures

1 Definition

- 1.1 ICAO defines a SID as a designated IFR departure route linking an aerodrome, or a specified runway at an aerodrome, with a specified significant point, normally on a designated ATS route, at which the en-route phase of a flight commences.
- 1.2 The UK additionally requires that all SIDs must be wholly contained within CAS.

2 SID Characteristics

- 2.1 SIDs consist of three distinct elements:
 - a) The ATS requirement to provide a link between aerodrome and/or departure runways to the en-route ATS system that is wholly contained within CAS. In promulgating a SID, complex departure clearances can be simplified, misinterpretations can be avoided and radiotelephony (RT) loading reduced.
 - b) The requirement to incorporate noise abatement procedures through the use of NPRs. SIDs must encompass and be wholly compatible with any existing NPR requirements as far as it is safe and practicable to do so (and vice versa).
 - c) SID designs must accord with the general and specific design principles detailed elsewhere in this document.
- 2.2 It is incumbent on the procedure designer(s) to devise a procedure that is:
 - a) **safe to fly** by each of the aircraft categories required to use it;
 - b) **meets the ATS requirement** for the safe integration and separation of traffic on closely spaced routes in terminal airspace;
 - c) **meets the environmental requirements** of the aerodrome operator as closely as practicable.
- 2.3 There are likely to be conflicts between competing air traffic management (ATM) and environmental considerations. ATS providers, aerodrome operators and aircraft operators must work closely with each other to derive the best possible compromise whilst still satisfying procedure design requirements. The safety of both the operation of the aircraft and the ATS system is paramount, and must be demonstrated at all times.
- 2.4 The methodologies and procedure design principles described in this document are not exclusive, but are those that will be accepted by DAP as meeting the airspace Safety Management requirement and suitable for national application.
- 2.5 Where procedure design staff identify an operational requirement that deviates from standard design principles, it will be necessary for the sponsor of the proposed procedure to submit a full Safety Assessment to demonstrate to DAP:
 - a) the procedure design criteria used and how they were derived;
 - b) that the procedure is safe for use by all aircraft categories expected to use it, within the normal flight envelope;
 - c) the safety of the ATS aspects of the procedure including the proposed RT phraseology to be used;

- d) that cockpit and ATS workload is acceptable;
 - e) the environmental impact of the procedure;
 - f) evidence of operational and environmental consultation.
- 2.6 *PANS-OPS* methodologies¹ are to be applied to establish the suitability of the intended design parameters for all aircraft intended to use the proposed procedures and to ensure that they will meet the aerodrome operator's operational objectives. Evidence will be required of consultation with aircraft operators and demonstration that the procedures can be flown safely within normal aircraft operating parameters. It is expected that such cases will be extremely rare and will not set a precedent.
- 2.7 Guidance material provided by the Department for Transport (DfT) outlining Government Policy and the Ministerial Directions to DAP is published in *Guidance to the Civil Aviation Authority on Environmental Objectives Relating to the Exercise of its Air Navigation Functions*², and should be referred to by sponsors of SIDs.
- 2.8 Instrument departure procedures established at UK military aerodromes are also referred to by military authorities as SIDs. These are not regulated by the UK CAA and are unlikely to be wholly contained within CAS.

3 General Principles³

- 3.1 The interaction between departure and arrival traffic patterns, especially where there are adjacent aerodromes, requires a highly standardised interface between the aerodromes and Area Control Centres (ACCs) to maximise airspace capacity.
- 3.2 Once the requirement for such routes has been determined, procedure designs are to be such that:
- a) flight along them does not require excessive navigational skill on the part of pilots;
 - b) they do not put the aircraft into a state which approaches its minimum safe operation with regard to speed and/or changes of direction;
 - c) they do not exceed the operating parameters of automated aircraft operating systems.
- 3.3 Although SID design criteria are set out in this document, DAP will consider alternative design proposals, provided such procedures are fully justified and are accompanied by comprehensive documentation to support the proposal.
- 3.4 SIDs facilitate:
- a) the maintenance of a safe, orderly and expeditious flow of air traffic;
 - b) the description of the route and procedures in ATS clearances;
 - c) an overall reduction in RT workload.
- 3.5 It is essential to consider environmental issues at aerodromes when considering SID requirements. SIDs are to be reviewed in the context of noise abatement procedures and/or routes to ensure that they are fully integrated and form a coherent operational entity serving both purposes. **However, noise abatement procedures shall not jeopardise the safe and efficient conduct of flight.**

1. ICAO *DOC 8168 PANS-OPS Vol II*, Part I, Section 3.

2. Available on the CAA and DfT websites (www.caa.co.uk and www.dft.gov.uk/aviation).

3. See also ICAO *Annex 11*, paragraph 3.7.1.2; ICAO *Annex 11*, Appendix 3; ICAO *Doc 9426 Air Traffic Services Planning Manual*, page I-2-4-4, paragraph 4.4 and Appendix A.

- 3.6 Any SID promulgated within the *UK AIP* is considered to be a “Notified Route”. Because such departure procedures are established at aerodromes served by CAS, the requirements of the Airspace Change Process must also be fully met. Details of the process to introduce or modify a SID are at Chapter 7¹.

4 Specific Principles

- 4.1 SIDs link the aerodrome, or a specified runway of the aerodrome, with a significant point at which the en-route phase of flight along a designated ATS route can be commenced whilst remaining wholly contained within CAS. The end point of the SID will be marked as a ground-based navigation aid or ATS significant point. SIDs must:
- a) provide for adequate terrain clearance²;
 - b) where practicable, segregate traffic operating along different routes and from traffic in holding patterns;
 - c) provide for the shortest practicable tracks;
 - d) be compatible with the performance and navigational capabilities of aircraft expected to use the procedure;
 - e) reduce as much as possible ATS and cockpit workload;
 - f) require a minimum level of air-to-ground radio communications;
 - g) take account of environmental impact and reflect noise abatement procedures;
 - h) provide, to the maximum extent possible, for uninterrupted climb to operationally advantageous levels with the minimum of restrictions;
 - i) be compatible with established loss of communication procedures;

4.2 Navigation

- 4.2.1 The following shall apply to routes requiring navigation with reference to ground-based navigational facilities:
- a) they shall relate to published facilities only;
 - b) the number of facilities shall be kept to the minimum necessary for navigation along the route and for compliance with the procedure;
 - c) they should require reference to no more than two facilities at the same time;
 - d) they shall be within the notified designated coverage of the facilities;
 - e) the facilities defining the procedure must be approved by the CAA.

1. See also Section J to *CAP 724 Airspace Charter*.

2. In accordance with ICAO *Doc 8168 PANS-OPS Volume II*.

- 4.2.2 Turns are not permitted below 500 ft above aerodrome level (aal). This is a UK safety requirement and supersedes the ICAO minimum permissible turn height of 394 ft.¹
- 4.2.3 SIDs shall be designed to enable aircraft to be navigated along the route without radar vectoring.²
- 4.2.4 Where the route requires a specified track to be followed, adequate navigational guidance must be provided. The necessary coverage of the navigational facilities shall be assessed by the procedure designer and demonstrated accordingly. Tracks without navigational guidance should be limited to a maximum length of either 10.8 NM (straight departures) or 5.4 NM (after completion of turns for turning departures).³
- 4.2.5 The radio navigational facility to be used for initial track or turning guidance should be identifiable in the aircraft prior to take-off.⁴
- 4.2.6 The route should identify significant points where:
- a) the specified track changes;
 - b) level restrictions apply;
 - c) the departure route terminates;
- 4.2.7 Significant points in conventional (i.e. non-RNAV) SID procedures should be established at positions either marked by the site of a radio navigation facility, preferably a VHF aid, or defined by:
- a) VHF Omnidirectional Range (VOR)/DME; or
 - b) VOR/DME and a VOR radial; or
 - c) intersection of VOR radials.
- 4.2.8 Significant points established at positions defined by VOR/DME should relate to the VOR/DME facility defining the track to be flown.
- 4.2.9 The use of dead reckoning (DR) legs and Non-Directional Beacon (NDB) bearings should be kept to a minimum.
- 4.2.10 The DME element of an Instrument Landing System (ILS)/Microwave Landing System (MLS)/DME installation may be used to define significant points along a track defined by other means. Such use must be limited to within the defined coverage area of the installation.
- 4.2.11 The first significant point of a SID procedure requiring reference to a radio navigation facility, should, if possible, be established at a minimum distance of 1 NM beyond the Departure End of the Runway (DER)⁵.
- 4.2.12 For RNAV SID design requirements see Chapter 5.
- 4.3 **Level Restrictions**
- 4.3.1 Level restrictions, where applicable, should be expressed in terms of minimum and/or maximum levels at which significant points are to be crossed. Where necessary, a level flight segment may be specified for separation between adjacent or intersecting

1. The UK Safety Requirement originates from a CAA Report into the Safety Aspects of Terminal Area Procedures, with particular reference to Noise Abatement, June 1974 (commissioned consequent to a Public Inquiry into an aircraft accident).

2. ICAO Doc 9426 *Air Traffic Services Planning Manual*.

3. ICAO Doc 8168 *PANS-OPS Vol II*, Part I, Section 3, Chapter 3.

4. ICAO Doc 9426 *Air Traffic Services Planning Manual*.

5. See Chapter 5, paragraph 2.

procedures, but in doing so account should be taken of cockpit workload immediately after take-off.

4.3.2 Level segments at minimum flight altitudes should not be required.

4.4 **Reporting Points**

The establishment of ATS-significant points (defined by ICAO five-letter designators) should be kept to a minimum. Cross-referencing to other conventional navigation aids should be included, when possible, including bearings in degrees True and Magnetic, distances in NM and appropriate WGS84 latitude and longitude values

4.5 **Specification of Tracks (application of Magnetic Variation)¹**

4.5.1 Tracks shown on conventional SID procedures will be presented in whole degrees Magnetic. RNAV SIDs will show Magnetic and True tracks, with the appropriate magnetic variation applied.

4.5.2 Whenever practicable, tracks "towards" (i.e. inbound to) a VOR or NDB should be specified in preference to tracks "going away from" (i.e. outbound from) a VOR or NDB.

4.5.3 Magnetic tracks to or from a VOR are determined by applying the published VOR station declination to the True track.

4.5.4 Magnetic tracks to or from an NDB are determined by taking the published magnetic variation at the departure aerodrome and applying it to the True track.

4.5.5 Dead reckoning tracks are determined by applying the local magnetic variation (typically that of the nearest aerodrome) to the True track.

4.5.6 **Procedure sponsors must review the published data at regular intervals to ensure that published magnetic tracks accord with the current magnetic variation applicable to the intended ground track².**

4.5.7 If necessary, and within the criteria specified in Chapter 4, SID designs should be adjusted to enable the desired nominal ground tracks to be achieved. Where this is not possible, the nominal ground track of the SID and associated swathes must be adjusted to reflect aircraft capabilities. Aerodrome operators must acknowledge that, when new SIDs are introduced, it may not be possible to accurately predict the achievable ground track of the procedures and the extent of the associated swathes of tracks actually flown by departing aircraft, until a period of observation of actual traffic data is available.

4.5.8 The navigational accuracy of tracks in relation to navigational facilities is detailed in Chapter 4.

1. Magnetic variations and VOR declinations for en-route navigation aids are published in the *UK AIP* at ENR 4.1 – Radio Navigation Aids – En-Route. Magnetic variations and rates of annual change for aerodromes are included in paragraph 2.2 of individual aerodrome entries in *UK AIP AD2*.

2. The declination at a VOR is the difference between Magnetic and True North resulting from the alignment of the VOR to Magnetic North at the time of calibration. The station declination at the VOR does not change until a recalibration is carried out (normally at 5-yearly intervals) and an allowance is made at the time of the calibration to take account of the calibration interval. The use of WGS84 coordinates to delineate the position at which each leg of the procedure commences and finishes will assist the accurate presentation of the original procedure and allow for easier application of Magnetic Variation (MagVar), when Magnetic tracks are shown. Details of declination settings for UK VORs are published in the *UK AIP* and are available from NATS Infrastructure Services.

5 Airspace Containment

- 5.1 SIDs shall be completely contained within CAS. Where it is necessary to contain a procedure above stepped controlled airspace bases, levels shall be specified which ensure that the flight profile remains at least 500 ft above the base of CAS.
- 5.2 Lateral containment of SIDs within CAS is, in the first instance, to be based upon the size and shape of the 'primary area' determined for obstacle clearance and applicable to the procedure design. Where competing airspace requirements preclude containment by primary area, containment of the nominal track defining the procedure may be less than that afforded by the primary area but shall be not less than 3 NM either side of nominal track¹.
- 5.3 In circumstances where the containment of the procedure within existing CAS (nominal track and primary area) cannot be achieved, sponsors will need to consider the need for speed limitations, modifying the design of the proposed procedure, or by increasing the amount of controlled airspace required.
- 5.4 The design of the SID procedure, therefore, becomes critical where airspace is limited, particularly with regard to the containment not only of the nominal track, but also the primary area. Procedure sponsors must be aware that there is a direct relationship between the design speed of the procedure, the angle of bank permissible and the amount of turn required. This impacts not only on the ability of the aircraft to follow the nominal track but, more importantly, also determines the overall dimensions of the primary and secondary protection areas that have also to be accommodated.
- 5.5 In most cases, the UK initial design speed of 210 KIAS will meet most SID procedure design requirements, although it is acknowledged that higher speeds may be applicable to some aircraft types so as to provide a 'cleaner' aircraft configuration on departure and reduce any environmental impact. In cases where a higher design speed is employed, consideration must be given to the impact of this on the containment of the primary area within CAS, as well as to the flyability of the nominal track.

6 Designation of SIDs

- 6.1 UK SID designation shall conform to the provisions of ICAO *Annex 11*².
- 6.2 Designators are allocated by DAP. In selecting designators, care will be taken to ensure that no confusion will arise in their practical use in voice communications through close similarities with other designators.

7 ATC Tactical Intervention

- 7.1 A SID will encompass any existing NPR and consideration must be given to environmental issues associated with its design. A departing aircraft should not be diverted from its assigned NPR unless:
- it has attained the altitude, height or (exceptionally) the distance which represents the limit of the noise abatement procedure (this is to be specified in the ATS unit's MATS Part 2 and *UK AIP AD-2.21*); or

1. Alternatively, procedures may have to be modified in order to reduce the primary area and therefore the containment and controlled airspace requirements. This will invariably be an iterative process.

2. ICAO *Annex 11 Air Traffic Services*, Appendix 3.

- b) it is necessary for the safety of the aeroplane (e.g. for the avoidance of severe weather or to resolve an immediate traffic conflict)
- 7.2 ICAO *Doc 9426 ATS Planning Manual* states that standard instrument departure and arrival routes should be designed so as to permit aircraft to navigate along the routes without radar vectoring. In high density terminal areas, where complex traffic flows prevail due to the number of aerodromes and runways, radar procedures may be used to vector aircraft to or from a significant point on a published standard departure or arrival route, provided that:
- a) procedures are published which specify the action to be taken by vectored aircraft in the event of radio communication failure; and
 - b) adequate ATC procedures are established which ensure the safety of air traffic in the event of radar failure.
- 7.3 If these requirements can be met, then ATC may tactically deviate an aircraft from the procedure in order to achieve the effective integration of traffic in the airspace and to meet ATS operational standing agreements. However, it should also be noted that the purpose of the SID is to provide a specific 'standard' departure clearance that takes into account aircraft performance, ATC requirements, obstacle clearance and airspace containment.
- 7.4 ATC tactical intervention may take the form of:
- a) vectoring or direct routing towards navigational facilities;
 - b) relaxation of speed controls (to the extent detailed in *CAP 493 Manual of Air Traffic Services (MATS) Part 1*);
 - c) clearance to climb above the levels specified in the procedure.
- 7.5 Exceptionally, and for traffic reasons only, it may be necessary to restrict an aircraft to a level below that specified in the procedure, but only for the minimum period necessary to ensure safety. In such cases, controllers must consider airspace containment where the base of CAS may be a significant factor.
- 7.6 **Controllers must also ensure that adequate terrain and obstacle clearance exists (as detailed CAP 493 MATS Part 1 with respect to controllers' responsibilities for terrain clearance) before deviating an aircraft from the tracks or speeds specified in the SID¹.**

8 Separation between Crossing or Converging Procedures

- 8.1 A complex interaction between departure and arrival routes from adjacent airports will often exist within Terminal Control Areas (TMAs). Routes may cross or converge and it is essential that vertical segregation of procedures is achieved at an adequate distance before the point of crossing or convergence. The design of routes within a TMA should aim to keep crossing tracks to a minimum.
- 8.2 The separation distances detailed in paragraph 8.4 below refer to conventionally-designed procedures and do not provide an assurance of non-radar separation between tracks. However, they are intended to assist in the provision of safe separation by ATS in a radar-managed ATS environment. It is assumed that at all times radar monitoring and intervention will be available to correct for gross navigational error or non-adherence to specified vertical profiles.

1. Relaxing published speed limits may also result in wider turns, which may take the aircraft outside the departure areas assessed for obstacle clearance.

- 8.3 **The responsibility for ensuring that standard separation exists between aircraft rests at all times with the radar controller.**
- 8.4 Where SIDs converge or cross, vertical separation must be established between the procedures no less than 7 NM before the nominal track centre-lines converge or cross (where the tracks are defined by VOR radials and are within 30 NM of the defining VOR(s)), provided that the controlling ATS unit is approved for the use of 3 NM minimum radar separation. Where tracks are defined by NDB bearings the distance is increased to 8 NM within 20 NM of the defining NDBs.
- 8.5 For procedures from adjacent aerodromes joining the en-route phase of flight at the same significant point, vertical separation must be provided between the procedures at the termination point unless there is an assurance (detailed in ATS instructions) that ATC will have issued further climb clearance before the end of the SID in all cases, and that the overall procedure length is at least 25 NM.

Chapter 4 Departure Procedure Design Requirements

1 Introduction

- 1.1 This chapter details the methodology to be used in designing the nominal track of a departure procedure and also the tolerances to be used in determining the departure area used for obstacle clearance assessment. It amplifies, for UK purposes, the criteria detailed in ICAO *Doc 8168 PANS-OPS Volume II* and *Doc 9368 Instrument Flight Procedures Construction Manual*.
- 1.2 Procedure design assumes that all engines are working normally on the aircraft. It is the responsibility of aircraft operators to develop contingency procedures that ensure obstacle clearance in the event of loss of power¹. Aerodrome operators are required to ensure that obstacle data in the vicinity of aerodromes is available to aircraft operators for this purpose. ATS and airport operators should also be aware that contingency procedures developed by aircraft operators may not necessarily coincide with published departure procedures; indeed such procedures may vary between aircraft types or between variants of the same aircraft type.
- 1.3 Specific RNAV SID design requirements are described in Chapter 5.

2 Start of Procedure

- 2.1 There are two basic types of departure – straight and turning. In both cases departure procedure design starts at DER^{2,3}.
- 2.2 Climb gradients required in the procedure for obstacle clearance or airspace design requirements are referenced to the position of DER.
- 2.3 The initial stage of the procedure is ‘straight ahead’ to the point at which the first required turn can be executed safely.

3 Obstacle Identification Surface (OIS) and Procedure Design Gradient (PDG)

- 3.1 It is necessary to distinguish between the obstacle clearance requirements of instrument departure procedures and any ATM issues (e.g. procedure interaction, procedure containment within CAS, the requirement to have established the minimum practicable amount of CAS, etc.). To that end, *PANS-OPS* criteria are to be employed when determining the OIS. However, UK airspace constraints are such that it may be necessary to apply additional UK-specific recommended criteria to satisfy airspace containment issues.
- 3.2 For obstacle assessment purposes, standard ICAO criteria apply. However, the UK stipulates a minimum turn height of 500 ft above aerodrome level (aal).⁴

1. See ICAO *Annex 6* and *Doc 8168 PANS-OPS Volume II*, Section 3, Chapter 2.

2. This differs from procedures associated with aircraft noise measurements (or noise limits), which are related to the distance from the start of the take-off run. Noise certification measurements are made at 6.5 km from the start of take-off run and this is normally the point at which noise penalty regimes are applied.

3. ICAO *PANS-OPS* states that DER is the end of the runway or, where a clearway is provided, the end of the clearway.

4. See Chapter 3, paragraph 4.2.2.

- 3.3 **OIS Analysis.** The OIS has an origin 5 m (16 ft) above DER and assumes the ICAO OIS gradient of 2.5%¹, based on the standard ICAO PDG of 3.3%. Where an obstacle penetrates the OIS, a steeper PDG is to be calculated to provide obstacle clearance of 0.8% of the distance flown from DER for straight departures; for turning departures it is the greater of either 0.8% of the distance flown from DER, or 90 m. This value shall be referred to on the SID chart as a MINIMUM OBSTACLE CLEARANCE CLIMB GRADIENT. This ensures obstacle clearance in accordance with *PANS-OPS* criteria.
- 3.4 Turns at altitude may be prescribed to accommodate:
- an obstacle located in the direction of a straight departure that must be avoided, or
 - an obstacle located abeam the straight departure track that must be overflown after the turn.
- 3.5 **UK-Specific Criteria**
- 3.5.1 Competing airspace demands and the CAA's requirement for any volume of CAS to be the minimum necessary to meet the requirements of a specific operation has led the CAA to conclude that, for ATM purposes, the following additional requirements could apply to SID designs:
- An initial climb to achieve a minimum of 500 ft aal at 1 NM DER.²
 - Thereafter, a minimum climb gradient for ATM purposes (or in order to satisfy CAS containment requirements where CAS already exists, and to ensure route separation requirements where necessary) is to apply. The selected ATM-related climb gradient is to be based upon the results of local traffic surveys undertaken to determine the actual climb performance of departures from the subject aerodrome.
 - 20° Angle of Bank (AOB) should be used for turns below 2,000 ft aal and 25° thereafter in the design of the nominal track.
- 3.5.2 **Departure Area.** The CAA's view is that, for ATM purposes, recommended practice is that construction of the departure area starts at 5 m (16 ft) above DER. Using an altitude and/or distance to fly to, the resultant nominal track and associate departure area for the SID can be created. This will provide an indication of the controlled airspace requirements for the procedure.
- 3.5.3 **Evaluation of Aircraft Performance.** Evaluation of aircraft performance³ has indicated that:
- aircraft can achieve heights in excess of 5 m over DER;⁴
 - climb gradients in excess of 3.3% can be achieved for ATM purposes;
 - the earliest turn can be achieved at 1 NM DER and not below 500 ft;

1. See ICAO *Doc 8168 PANS-OPS Volume II*, Section 3, Chapter 2.

2. However, it is recognised that in exceptional circumstances (e.g. the presence of an exceptionally long clearway), it may be necessary for this initial climb to achieve a minimum of 500 ft aal no later than 1 NM from End of Concrete, where a turn at altitude will result.

3. NATS Department of Operational Research and Analysis (DORA) study, *Analysis of Achieved Aircraft Performance Immediately After Departure* – Interim Report July and Final Report November 1999.

4. Note that for the purposes of the DORA Study, evaluation traffic samples were taken at London Gatwick, Heathrow and Stansted airports. Neither Gatwick nor Stansted has a clearway; Heathrow Rwy 27R's clearway is 77 m long. It is therefore assumed that, for the purposes of this document, DER equated to End of Concrete.

- d) a nominal 20° AOB for the first turn after departure below 2,000 ft is compatible with demonstrated aircraft performance, and that a 25° AOB could be applied for subsequent turns¹.

4 Turns

4.1 Initial Turn

- 4.1.1 The **earliest** point at which the first turn shall be specified is the point at which all aircraft will have achieved 500 ft aal. This point is determined by:

- a) the nominal aircraft height at DER; plus
- b) the additional distance required to reach 500 ft aal.

- 4.1.2 Under no circumstances will turns closer than 0.6 NM beyond DER be specified in the procedure design unless arising through 'turn at an altitude'.

- 4.1.3 Where, on the basis of traffic study and evaluation, the aerodrome operator can demonstrate that all aircraft that are intended to use a procedure have consistently achieved a greater climb gradient in the initial stages of the departure, DAP will accept a climb gradient in excess of 3.3% where it is desirable to specify a first turn closer than 1 NM from DER for specific environmental purposes. In such cases the aerodrome operator must support the proposal with evidence that:

- a) a traffic study has been undertaken;
- b) the proposed climb gradient is within the flight manual performance requirements of user aircraft;
- c) noise preferential runway requirements (e.g, potential for tailwind departures) will not compromise the proposed climb gradient;
- d) the performance of future aircraft types has been taken into account, as far as possible;
- e) the requirements of safety regulation and aircraft operators are met.

4.2 General Considerations

- 4.2.1 When assessing the procedure for obstacle clearance the minimum obstacle clearance (MOC) criteria specified in *PANS-OPS*² shall be used. Turns will normally be specified as commencing at a fix or at a navigational facility, to turn onto a specified track (VOR radial, NDB bearing or DR track).

- 4.2.2 If required, turns may be specified at an altitude. Procedures incorporating turns at an altitude should only be used to avoid straight-ahead obstacles or where exceptional circumstances dictate.

- 4.2.3 The **nominal** track for the procedure is therefore designed using a specific set of nominal parameters for speed, bank angle, altitude and temperature in still air. However the **actual** track achieved by individual aircraft around turns will depend on the mass of the aircraft, its speed, the bank angle applied, atmospheric conditions (temperature, altitude, wind), navigational accuracy (of both navigational aids and aircraft equipment) and flight technical tolerances (pilot reaction time and the time

1. ICAO *Doc 8168 PANS-OPS Volume 2*, Section 3, Chapter 2 states that, before any turn greater than 15° may be executed, a minimum obstacle clearance of 90 m (295 ft) must be reached (by aeroplanes). Alternatively, 0.8% of the distance from DER may be used, if this is higher. This minimum obstacle clearance must be maintained during subsequent flight.

2. ICAO *Doc 8168 PANS-OPS Volume II*, Section 3, Chapter 2.

taken to establish the bank angle) and any operating limitations that may apply to the aircraft.

- 4.2.4 Tolerances for the navigational and technical variables are outlined in Section 7 below and detailed in *PANS-OPS*¹. National criteria for 'worst case' wind effects are to be applied to determine containment areas for obstacle assessment².

4.3 Turn Radius

The nominal turn radius is determined by using still air conditions at International Standard Atmosphere (ISA)+15, procedure design speed and bank angle, and nominal aircraft altitude based on the nominal procedure design climb gradient.

4.4 Turn Altitude

- 4.4.1 The altitude to be used in the construction of the turn protection area is to be based on the elevation of the DER plus either the height achieved by an aircraft based upon a 10% climb gradient to the turning point, or that achievable by the end of the turn based upon the nominal design gradient used for the design, whichever is the greater.
- 4.4.2 Where altitude restrictions (e.g. overlapping procedures, existing airspace structures, etc.) preclude the application of this value, the turn protection area is to be based upon the promulgated altitude to be achieved by the end of the turn.

5 Speed

- 5.1 The recommended speed used for the nominal track in procedure design should be 210 KIAS up to 3,000 ft aal (or the end of the first turn, as appropriate), and 250 KIAS thereafter. This is found to be a suitable average to accommodate a wide mix of aircraft types. However, if an operational requirement is established to provide a separate procedure specifically for aircraft of lower performance (e.g. Category A and B aircraft) then a lower Indicated Airspeed (IAS) may be used and annotated on the procedure charts accordingly.
- 5.2 Where required, reduced speeds may be necessary to accommodate a procedure's initial turn, either to reflect environmental, ATC or airspace containment requirements.
- 5.3 Before submitting any such procedures for approval, the sponsor will be required to justify the design criteria used and demonstrate the flyability of the procedure.³
- 5.4 Any speed limitations must be promulgated as 'Departure limited to xxx KIAS maximum', etc. The associated turn protection areas will be constructed to these speeds.
- 5.5 It is acknowledged that higher speeds may be applicable to some aircraft types in order to permit a 'cleaner' aircraft configuration on departure and reduce any environmental impact. In cases where a higher design speed is employed, consideration must be given to the impact of this upon primary area containment within CAS, as well as to the flyability of the nominal track.

1. ICAO *Doc 8168 PANS-OPS Volume I*, Part 1, Section 2, Chapter 2 and *Volume II*, Part 1, Section 2, Chapter 2.

2. The use of "UK Winds" provides a significant benefit over the use of "ICAO Winds" in reducing the size of the protection areas required for obstacle clearance and airspace containment. However, for the purpose of UK departure procedure design, the ICAO Wind of 30 kt should be used up to altitude 3,000 ft and thereafter the UK Wind criteria (40 kt plus value of height in thousands of ft. Example: 4,000 ft UK wind determined as 40 + 4 kt = 44 kt; 6,000 ft UK wind determined as 46 kt, etc.).

3. Procedure sponsors must show that aircraft operators have considered the design of the procedure and have agreed that it is operationally acceptable.

6 Bank Angle

- 6.1 See paragraph 3.5.1.
- 6.2 Bank angle limitations are not specified in published procedures.

7 Navigational Tolerances

- 7.1 All navigational facilities and systems have accuracy limitations. Therefore, the nominal points identified for navigational fixes and significant points are not precise but will lie within an area that surrounds the nominal fix or facility position. The area formed by the tolerances of the navigational facilities used to define fixes is known as the Fix Tolerance Area.
- 7.2 The dimensions of the Fix Tolerance Area are determined by the system accuracy of the navigational facilities which supply the information to define the fix. The factors from which the accuracy of the system is determined result from:
 - a) the accuracy with which the signal in space can be provided by the navigational facilities;
 - b) the accuracy with which a) can be measured by setting up and monitoring systems where appropriate;
 - c) the accuracy with which the aircraft systems can interpret and display the data provided by the navigational facilities;
 - d) the speed and accuracy with which the pilot or the aircraft systems (e.g. in the case of bank establishment) can react to the data displayed.

The fix tolerance areas are formed by applying the positive and negative tolerances to the tracking and intersecting radials, bearings or arcs, as appropriate, to the nominal fix position.

- 7.3 The tolerances described above are combined on a root sum square (RSS) basis to provide system accuracies as detailed in *PANS-OPS*¹.

8 ATS Intervention

- 8.1 A speed limit of 250 KIAS is normally applied to procedures below FL100 within UK terminal airspace for ATS separation or airspace purposes.
- 8.2 Unnecessary removal of the speed limit by controllers in the early stages of flight, allowing aircraft to accelerate to higher speeds than are catered for in the procedure design, may compromise the ability of the pilot to adhere to the intended nominal track and may compromise obstacle clearance and noise abatement requirements.
- 8.3 Speed limits should not be relaxed by ATC until at least 1,000 ft obstacle clearance is assured.

9 End of a SID

- 9.1 The SID procedure ends at a Significant Point on a designated ATS route at which the en-route ATS system is joined. The designator of the ATS significant point at the end of the SID procedure (navigation aid identifier or ICAO 5-Letter Name Code (5LNC))

1. ICAO *Doc 8168 PANS-OPS Volume I*, Part 1, Section 2, Chapter 2 and *Volume II*, Part 1, Section 2, Chapter 2.

will normally determine the designation of the SID procedure in accordance with ICAO *Annex 11*, Appendix 3.

- 9.2 The published upper limit of the procedure must ensure that the aircraft continues to be contained wholly within CAS and is also at, or above, the minimum altitude or flight level necessary for the next phase of flight.

10 Promulgation

See Chapter 9.

Chapter 5 Additional RNAV Departure Procedure Design Requirements

1 Introduction

- 1.1 The European ATM Master Plan and the supporting Eurocontrol *Strategic Guidance in Support of the Execution of the European ATM Master Plan*¹ sets out the requirements for the introduction of RNAV procedures throughout the ECAC States.
- 1.2 When airborne RNAV systems were first brought into service, and before procedure design criteria and conventions were fully developed, a number of States introduced RNAV routes that were overlaid on existing conventional routes, particularly in terminal airspaces. This was intended to allow operators to draw some benefit from their investment in RNAV without altering existing traffic flows. Where such overlays have been based on existing published conventional procedures they are, at best, a temporary measure and do not provide the increased flexibility and capacity that can be expected from properly developed RNAV procedures. The use of such overlays in the UK will be kept to a minimum.
- 1.3 RNAV procedures will be based upon procedure design requirements detailed in this document, ICAO *PANS-OPS*², ICAO *Doc 9368*³, Eurocontrol⁴ and other guidance material listed at Appendix A.
- 1.4 ECAC policy requires all new RNAV procedures introduced in terminal airspace in the ECAC Region to be designated as P-RNAV procedures and that all existing RNAV procedures shall be redesigned to meet P-RNAV criteria. P-RNAV is not yet mandated for use in UK airspace.
- 1.5 The Performance Based Navigation (PBN) concept specifies RNAV system performance requirements in terms of the accuracy, integrity, availability, continuity and functionality needed for the proposed operations in the context of a particular Airspace Concept, when supported by the appropriate navigation infrastructure. In that context, the PBN concept represents a shift from sensor-based to performance-based navigation. Performance requirements are identified in navigation specifications, which also identify the choice of navigation sensors, and equipment that may be used to meet the performance requirements. Under PBN, generic navigation requirements are defined based on the operational requirements. **A Navigation Specification is either an RNP specification or an RNAV specification. An RNP specification includes a requirement for on-board self-contained performance monitoring and alerting while an RNAV specification does not.**
- 1.6 Under PBN, different levels of route structure sophistication and track-keeping accuracy requirements for ATS purposes are designated as either RNAV or RNP. The following are applicable to UK terminal airspace procedures (excluding approaches):
- a) **B-RNAV (Basic RNAV).** B-RNAV (referred to by ICAO as RNAV-5) is the simplest form of RNAV but is not applicable to terminal airspace operations below Minimum Sector Altitude or ATS Surveillance Minimum Altitude.

1. Eurocontrol *Strategic Guidance in Support of the Execution of the European ATM Master Plan (30 March 2009)*.

2. ICAO *Doc 8168 PANS-OPS Volumes I and II*.

3. ICAO *Doc 9368 Instrument Flight Procedures Construction Manual*.

4. Eurocontrol *Guidance Material for the Design of Terminal Procedures for Area Navigation (DME/DME, B-GNSS, Baro-VNAV & RNP-RNAV)*.

- b) **P-RNAV (Precision RNAV).** P-RNAV (referred to by ICAO as RNAV-1) provides for greater accuracy of navigation for ATS purposes and requires a greater sophistication of specified aircraft equipment capability and integrity, which will ensure that the aircraft remains within 1 NM of the intended track for 95% of the time. The greater track-keeping accuracy will, in time, allow ATS routes to be more closely spaced than for conventional navigation. P-RNAV or better will be the minimum requirement necessary to bring capacity benefits to terminal airspace operations.
- c) **Advanced RNP 1.** A future terminal airspace application utilising RNP, RNP 1 is intended to take advantage of RNAV systems with on-board performance monitoring and alerting, enabling the possibility of applications with reduced route spacing. The navigation specification will also require advanced functionality including RF Path Terminators. Advanced RNP 1 is not expected to be implemented in UK terminal airspace until after 2015.

1.7 In each case the accuracy achieved depends on both the sophistication of navigational aircraft equipment and the availability of a suitable navigation aid infrastructure.

2 RNAV Departure Procedure General Design Principles

- 2.1 In general, the design principles applicable to conventional procedures are to be applied, but with additional stringencies and constraints being necessary as required to satisfy RNAV procedure design criteria¹.
- 2.2 Significant points used in RNAV procedure design are known as **waypoints**. These are coded into navigation databases and must be specified either as 'flyby' or 'flyover' waypoints. Individual legs are then defined by heading, waypoint, waypoint transition, path terminator, speed constraint or altitude constraint as appropriate.
- 2.3 For flyby waypoints, RNAV systems will compute a distance prior to the waypoint at which the turn is initiated to intercept the track to the next waypoint. This computation takes account of the aircraft speed, the angular change of track required and the bank angle available to the system.
- 2.4 For flyover waypoints, the RNAV system will initiate a turn on passing the waypoint and will compute a track to regain the track between the waypoints or to route directly to the next waypoint, or to intercept a specific track to the next waypoint, depending on the coding applied within the navigation database. This type of waypoint provides relatively poor controlled performance and should only be used when overflight of the waypoint is essential.
- 2.5 The following general principles apply to the creation and use of waypoints for RNAV terminal procedures:
 - a) RNAV procedures should be designed using the fewest number of waypoints possible.
 - b) Waypoints must be established at:
 - i) each end of the RNAV route;
 - ii) points where the route changes course;
 - iii) points where altitude restrictions apply or cease;
 - iv) points where speed restrictions apply or cease;

1. See also ICAO *Doc 8168 PANS-OPS Volume II*, Part III, Section 1, Chapter 1 and Section 3, Chapter 1, paragraph 1.1.1.2.

- v) holding fixes;
 - vi) other points of operational benefit.
- c) Flyby waypoints should be used whenever possible.
 - d) Flyover waypoints should be used exceptionally and only when operationally necessary.
 - e) RNAV waypoints must be defined as WGS 84 co-ordinates in latitude and longitude (1/100 second resolution is required for runway thresholds/Missed Approach Points (MAPts)).¹
 - f) The procedure shall not require the flight crew to manually modify waypoint co-ordinates or procedures extracted from the navigation database.

2.6 Waypoint Naming

- 2.6.1 Waypoints are deemed to be either 'strategic' or 'tactical' depending on their position and function, and must be named in a manner appropriate for use in navigation databases.² Waypoint designators are approved by DAP.
- 2.6.2 Where the waypoint is used 'strategically' (i.e. in relation to the ATS route structure itself) and is therefore likely to be used routinely in RTF exchanges, a standard ICAO five-letter significant point name code is allocated.
- 2.6.3 Waypoints intended to be used on a 'tactical' basis (i.e. unique to a specific procedure), but still needing to be contained in the navigation database for procedure definition purposes other than as an ATS significant point (and therefore less likely to be used in Radiotelephony (RTF) exchanges), are to be allocated alphanumeric designators.
- 2.6.4 If a waypoint coincides with a ground-based navigation aid, the three-letter navigation aid identifier is used. Common waypoints (i.e. common to two or more different procedures) shall be designated by ICAO 5LNCs.

2.7 Path Terminators

- 2.7.1 Terminal airspace procedures have traditionally been described in AIPs in text and diagrammatic form. However, aircraft navigation systems must be provided with route data in a format that can be accurately and consistently processed by navigation database providers. The navigation database uses data that is coded in accordance with the industry standard *ARINC 424 Navigation System Database Specification*. Standard Leg Types and Path Terminator codes are used to define each leg of the procedure from take-off until the en-route structure is joined.
- 2.7.2 There are at present 23 different Path Terminator codes, although most navigation systems only implement a subset of these. Path Terminators define the type of flight path leg between waypoints and where and how the leg terminates, and will therefore determine how the aircraft adheres to the nominal intended track.³
- 2.7.3 Path Terminators applicable to P-RNAV or Required Navigational Performance (RNP) SID procedures are as follows:
 - a) **CA** Course to an Altitude.
 - b) **CF** Course to a Fix. This should be used with caution as earth convergence and magnetic variation mismatches and the fact that the course is usually coded to the nearest whole degree may result in the course not being coincident

1. See ICAO *Annex 15*, Appendix 7.

2. Waypoint policy is described in *Use and Allocation of RNAV Waypoints* (DAP, October 2008).

3. Their use is described in detail in the Eurocontrol *Guidance Material for the Design of Terminal Procedures for Area Navigation (DME/DME, B-GNSS, Baro-VNAV & RNP-RNAV)* and in *RTCA DO-201A/EUROCAE ED-77*.

with the transition waypoint. There is also an issue with CA/CF regarding high performance aircraft on long runways with the course passing within 2 NM of DER. However, CA/CF is a good solution for many noise abatement turns after departure.

- c) **DF** Computed track Direct To a Fix
- d) **FA** Course from a Fix to an Altitude. This should not be used on initial departures for non-Global Navigation Satellite System (GNSS) equipped aircraft as it may induce early turns caused by misaligned Inertial Referencing Units (IRUs).
- e) **FM** Course from a Fix to a Manual Termination. Used for Standard Instrument Arrival Routes (STARs) when ATS want track to be maintained after the RNAV STAR.
- f) **HA** Holding/Racetrack to an Altitude. A holding pattern path that automatically terminates at the next crossing of the hold waypoint when the aircraft's altitude is at, or above, the specified altitude.
- g) **RF** Constant Radius Arc to Fix. Also referred to as a Fixed Radius Turn and only available in Performance Based Navigation (PBN)¹ systems.
- h) **TF** Track to a Fix.
- i) **VA** Heading to an Altitude. Often used on departures where a heading rather than a track has been specified for climb-out. The segment terminates at a specified altitude without a terminating position. In a P-RNAV SID context VA fulfils a design function requirement and not part of the procedure itself.
- j) **VI** Heading to Intercept. Used to define a route segment that intersects the following segment and where no intercept point or turn point has been defined. In a P-RNAV SID context VI fulfils a design function requirement and not part of the procedure itself.
- k) **VM** Heading to a Manual Termination. Used for STARs when ATS want headings after the RNAV STAR.

3 RNAV Departure Procedure Design Features

3.1 Beginning of the Procedure

- 3.1.1 The procedure starts at DER with the first leg ending at a reference point on the extended runway centreline at which the PDG passes 500 ft aal.
- 3.1.2 A reference point is located at DER for the purposes of constructing the obstacle clearance areas. This is a design function requirement and not part of the procedure itself.

3.2 Initial Turn

The initial turn is specified by a waypoint on the extended runway centreline at or beyond the point at which the PDG reaches 500 ft aal. When the initial turn is designated by a flyby waypoint this distance must additionally take account of the turn anticipation distance so that turns are not initiated below 500 ft. Earliest and latest turning point definitions can be found in ICAO *PANS-OPS*.²

1. The Performance Based Navigation (PBN) concept specifies aircraft RNAV system performance requirements in terms of accuracy, integrity, availability, continuity and functionality needed for the proposed operations in the context of a particular Airspace Concept. Performance requirements are identified in navigation specifications, which also identify the choice of navigation sensors and equipment that may be used to meet the performance requirements.

2. ICAO *Doc 8168 PANS-OPS Vol II*, Part III, Section 3, Table III-2-2-1 Earliest and latest turning point definition.

3.3 Turns

3.3.1 Three kinds of turns may be prescribed for departure procedures:

- a) turn at a flyby waypoint;
- b) turn at a flyover waypoint; and
- c) turn at an altitude.

3.3.2 Whenever possible, **turn at a flyby waypoint** is to be used, where the navigation system anticipates the turn onto the next route leg.

3.3.3 A flyover waypoint should be used exceptionally and only where it is operationally necessary.¹

3.3.4 Whenever possible, turns at an altitude/height (also known as “conditional transitions” for database coding purposes) need to be avoided in order to preclude the dispersion of tracks at the turn. Nevertheless, turns at an altitude/height may be an advantage where noise mitigation is not an issue or where it is considered preferable to disperse tracks.

3.3.5 In future, with the availability of RF legs (defined in terminal airspace by the RF Path Terminator), aircraft will be able fly a specific turn with a defined radius, plus start and end points.

3.3.6 RF legs in the terminal area will provide the most accurate, predictable and repeatable turn and are expected to become the preferred method for turns. The use of RF legs should only be considered when operational circumstances demand its application and/or the population of aircraft using a given procedure are RF-capable.

3.4 Minimum Distance Between Turns

3.4.1 To prevent turning waypoints being placed so close to each other that RNAV systems are forced to bypass them, a minimum distance between successive waypoints must be established. Each leg must be long enough to allow the aircraft to stabilise after the first turn prior to commencing the next. This is particularly important where terrain clearance is a factor in the procedure.²

3.4.2 The minimum distance between waypoints (minimum segment length) is determined by the intercept angle with the previous leg and the type of waypoint (transition) at each end of the leg. Thus five situations can occur:

- a) flyby to flyby;
- b) flyby then flyover;
- c) flyover then flyover/fixed radius;
- d) flyover then flyby;
- e) fixed radius then flyby.

3.4.3 In some combinations, the direction of the second turn (same direction or opposite direction) is a factor in the minimum segment length. Tables detailing the minimum segment lengths for various track angle change/True Air Speed/angle of bank combinations are given in the Eurocontrol *Guidance Material for the Design of Terminal Procedures for DME/DME and GNSS RNAV*, which supplements the Minimum Stabilisation Distance tables given in ICAO *PANS-OPS*.

1. Flyover waypoints associated with track changes are not suitable for Class A GNSS equipment.

2. It is unwise to have consecutive legs of minimum length as some RNAV systems may derive an optimum course that may contravene the obstacle clearance area boundaries. Additionally some RNAV systems will not accept leg distances that are less than 2 NM regardless of the turn logic.

3.5 **Maximum Track Change**

- 3.5.1 In order for aircraft to properly execute turns in the designed RNAV procedure, each single specified track change (the connection between two successive straight segments) shall not be less than 5°.
- 3.5.2 Turns should not normally exceed 120°. Where required, turns in excess of 120° continuing in the same direction will require two or more flyby waypoints.
- 3.5.3 Changes in the direction of turn will require the designated stabilisation distance to be applied between each manoeuvre.
- 3.5.4 Wherever possible in departure procedures, flyover or conditional turns involving track changes greater than 120° should not be used as the speed and climb performances of different aircraft types varies considerably. As a result, it is difficult to ensure that all aircraft types and operational circumstances are adequately catered for and accurate track adherence cannot be assured¹.
- 3.5.5 Procedure designers should therefore consider the alternative use of two consecutive turns in the same direction, with an appropriate stabilisation distance between, in order to achieve the same objective as an extended single turn.
- 3.5.6 However, where a track change of greater than 120° cannot be avoided it becomes a “free turn back” to the next waypoint with an undefined nominal track between the two waypoints (i.e. the tracks actually achieved would be subject to such dispersion that a particular required track could not be specified). This would therefore become a factor in track containment requirements both for ATS separation purposes (against other adjacent procedures) and for environmental requirements. In future PBN environments, fixed radius turns (RF path terminators) will become the preferred option for all turns in excess of 90°.

4 **Waypoint Fix Tolerance**

- 4.1 In RNAV procedures the navigational accuracy is defined in terms of the across track tolerance (XTT) and along track tolerance (ATT) associated with each waypoint, based on the position and accuracy of each reference navigation aid used for the procedure. The calculations necessary to derive the XTT and ATT values, and also how the XTT and ATT are used to derive the Area Widths (AWs) for track containment and obstacle clearance assessment, are detailed in *PANS-OPS*².
- 4.2 For DME/DME procedures it is not always possible to know which DME stations the airborne system will be using at any given time. Moreover, the number and relative location of the DME stations that an RNAV system can use will, together with the track orientation, affect the accuracy of the navigation solution.
- 4.3 Aircraft must be within the declared operational coverage (DOC) of the facilities used³ and the bearings from the aircraft to the facilities must subtend an angle of between 30° and 150°.
- 4.4 Procedure designers (through the procedure sponsor) must establish the navigation aid availability at each waypoint along the route based upon the aircraft height determined by the PDG and the distance from DER.
- 4.5 The ATT and XTT and AW values at each waypoint should then be calculated or taken from the tables in ICAO *Doc 8168 PANS-OPS Volume II*, Part III, Section 1, Chapter 3.

1. A maximum of 90° should be the design goal with 120° allowed for exceptional cases.

2. ICAO *Doc 8168 PANS-OPS Vol II*, Part III, Section 3 - Procedure Construction.

3. But note that an aircraft will use the DME solution that it considers to be the optimum, regardless of DOC.

- 4.6 In the initial stages of the departure, where aircraft may be below the coverage areas of sufficient DME or VOR facilities to provide accurate updating of the navigation computer, it is likely that position updates will be derived solely from Inertial Reference System (IRS) or GNSS input. The accuracy of navigation data provided by an IRU is directly related to the accuracy of the last alignment/update and the time that has elapsed since the last update.
- 4.7 The growth of position error that is inherent within an IRU limits the amount of time that it can be used for RNAV operations. In order to reduce the time lapse between the last update and the commencement of the departure procedure, some aircraft systems include an automatic "runway update" function for use at the start of the take-off run¹.

5 Calculation of the First Waypoint – Consideration of ATT

- 5.1 The UK has considered the relationship of ATT in the calculation of the position of the first waypoint in any RNAV departure procedure. It is recognised that the current *PANS-OPS* criteria may restrict the point at which the first turn may be initiated and this could have significant impact on runway utilisation and departure separation requirements.
- 5.2 For a Fly-by waypoint the minimum distance from DER to the first waypoint is the sum of;
- a) turn initiation (which will vary with turn angle), AOB and True Airspeed (TAS);
 - b) ATT; and
 - c) the distance required for the aircraft to achieve minimum turn height (above DER).
- 5.3 Taking into consideration the ICAO criteria for height at DER, and minimum PDG (3.3%), the minimum turn height equates to 394 ft. However, it is UK policy that the lowest turn height is to be 500 ft. Applying an assumed height of 5 m (16 ft) over DER and a minimum PDG of 8%, aircraft will achieve 500 ft at 1 NM beyond DER; therefore the turn point shall be no closer to DER than 1 NM.
- 5.4 In designing departure procedures incorporating NPRs, the inclusion of ATT in the calculation protects aircraft equipment from identifying the first waypoint as being closer to DER by a maximum distance equal to ATT. Otherwise, the aircraft's lateral navigation system (if engaged) could attempt to commence the first turn earlier.
- 5.5 If ATT has not been factored when positioning the first waypoint, an early turn could be initiated (automatically by the flight guidance systems) before an aircraft reaches minimum turn height. Given that the ATT value could be of the same magnitude as the distance required to reach 500 ft, the turn demand could, in extremis, occur at DER.
- 5.6 The ATT values for DME/DME RNAV will vary according to the number of DMEs available, whether the ground stations are commissioned pre- or post-1989, and the altitude of the turn. For the purposes of UK design, all DMEs are assumed to be post-1989.
- 5.7 Flight crews should be aware that UK policy states that no turns should be made below 500 ft aal. However, if before reaching that height the aircraft is already under the control of the flight guidance system and autopilot, this requirement could be violated. It seems that techniques are many and varied and the point at which the

1. Where automatic updates are not available, alignment of systems prior to entering the runway may place at predefined Quick Align Points. A 'quick align' may take up to 30 seconds.

autopilot is coupled to the navigation system will vary from operator to operator. Some systems (e.g. Boeing) will not permit automatic turns below 400 ft aal.

- 5.8 When designing an RNAV departure procedure and constructing the **nominal** departure track, the following considerations should be adopted:
- a) Where existing NPRs permit, current *PANS-OPS* criteria must be applied in full (and ATT included in the calculation).
 - b) Where existing NPRs cannot be replicated when applying *PANS-OPS* criteria, a prominent warning is to be added to published departure charts instructing crews to monitor the first turn to ensure that it is not initiated below 500 ft aal.
 - c) Alternatively, where existing NPRs cannot be replicated, procedure sponsors (i.e. the affected airport) must consider adjusting the NPR to satisfy procedure design considerations and constraints
- 5.9 **For the construction of protection areas for obstacle analysis purposes, the criteria published in *PANS-OPS*, plus additional requirements as stipulated in this chapter, must be applied.**

6 Navigation Aid Coverage

- 6.1 It is the responsibility of the State to ensure that sufficient navigation aids are provided and are available to achieve the approved operation. In terms of en-route navigation aids, in the UK this responsibility rests with NATS Ltd as part of their En-Route ATS Licence requirements. With regards to other navigation aids (i.e. related to specific aerodromes, e.g. DMEs), airport operators (as procedure sponsors) must ensure sufficient facilities are available to support instrument procedures.
- 6.2 Procedure designers are responsible (through the procedure sponsor) for determining that adequate navigation aid coverage is available to support a procedure. This must be established during the procedure design and validation phases.
- 6.3 Any navigation aid that is critical to the operation of a specific procedure must be identified in the *UK AIP*. It should be noted that procedures may have to be suspended if a critical navigation aid becomes unavailable.
- 6.4 ATS providers must ensure that, where ground-based navigation aids are published as being available for use within a designated RNAV airspace, there are sufficient serviceable aids to provide a continuous determination to the required accuracy of an aircraft's position within that airspace.
- 6.5 ATS providers must also ensure that all ground-based navigation aids likely to be used by aircraft navigation systems in departure procedures are approved for such use in accordance with the provisions of the Air Navigation Order.¹

7 Multiple Navigation Infrastructures

Procedures should be designed to provide the optimum flexibility to users and to enable inputs from as wide a variety of navigation infrastructures as possible. This allows aircraft with multi-sensor RNAV systems to continue on a procedure in the event of a primary navigation sensor or navigation aid infrastructure failure.

1. CAP 393 Air Navigation: The Order and the Regulations.

8 ATC Tactical Intervention

Any ATC tactical intervention should be considered as exceptional, as there is an expectation that the aircraft will follow a SID without ATC intervention – this becomes critical when aircraft employ their flight management systems. Consideration must, therefore, be given to any subsequent actions that need to be taken to resume the planned departure route following any such intervention. This may require ATC to nominate the specific route that the aircraft should follow, rather than simply state “resume standard instrument departure”. This becomes particularly important when procedure-specific waypoints are used to designate P-RNAV SID tracks.

9 Promulgation

See Chapter 9.

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Chapter 6 Noise Preferential Routes (NPRs)

1 Definition

- 1.1 There is no ICAO definition of the term 'NPR'. Where established, NPRs seek to reduce the noise impacts of departing aircraft by avoiding, as far as practicable, overflight of noise-sensitive areas in the vicinity of the aerodrome.
- 1.2 ICAO states that noise abatement procedures shall only be implemented where a need for such procedures has been determined.

2 Responsibilities

- 2.1 UK Government Policy states that the responsibility for the control of aircraft noise in the vicinity of an aerodrome rests with the aerodrome operator. In meeting this obligation aerodrome operators have a duty, under the Civil Aviation Act¹, to consult with the Airport Consultative Committee where one is established or, if no such Committee exists, with all Local Authorities within whose boundaries the airport lies, on all matters affecting the operation of the aerodrome.
- 2.2 Government also places an obligation upon DAP, through Ministerial Directions, to ensure that environmental matters are considered at all stages of airspace and procedure planning, design and operation. DAP is also required by the Directions to ensure that appropriate consultation has been carried out with local stakeholders prior to Aerodrome Operators advising DAP of their intention to introduce or modify existing NPRs, and of the consultation process employed. Where proposed changes to airspace arrangements may have a detrimental effect on the environment, DAP must secure the approval of the Secretary of State for Transport before any such changes are implemented.
- 2.3 DfT guidance outlining Government policy regarding environmental issues and the Ministerial Directions to DAP² is to be taken into account by NPR sponsors.
- 2.4 DAP regulates the design of NPRs within CAS through the *Airspace Charter (CAP 724)* and will provide such guidance and assistance as may be required. Additional guidance on the application of the airspace change process can be found in *CAP 725 CAA Guidance on the Application of the Airspace Change Process*.

3 General Principles³

- 3.1 NPRs may be established to ensure that departing aircraft avoid, as far as practicable, overflight of noise-sensitive areas in the vicinity of the aerodrome. However, noise abatement procedures shall not be implemented except where a need for such procedures has been determined **and shall not jeopardise the safe and efficient conduct of flight**.
- 3.2 Various measures may be taken by aerodrome operators and by aircraft operators to control and alleviate aircraft noise in the vicinity of airports. These can include the

1. Section 35, Civil Aviation Act 1982.

2. Guidance to the Civil Aviation Authority on Environmental Objectives relating to the Exercise of its Air Navigation Functions, available at the CAA or DfT websites (www.caa.co.uk or www.dft.gov.uk/aviation).

3. See ICAO *Annex 16 Volume I*, Part IV 'Assessment of Aircraft Noise', Part V 'Balanced Approach to Noise Management' and ICAO *Doc 8168 PANS-OPS Volume I*, Section 7.

establishment of NPRs, noise preferential runways and noise limits with monitoring and penalty regimes. Similarly, aircraft operators may employ noise abatement techniques such as thrust reductions after departure which may be necessary to meet noise limit regimes at particular airports.

- 3.3 The criteria to be used by aerodrome operators and aircraft operators in determining the appropriate Noise Abatement Procedures are detailed in *PANS-OPS*¹.
- 3.4 NPRs must be compatible with the initial stages of SIDs (where established, and vice versa). As with SIDs, once the requirement for NPRs has been determined, the design of these should ensure that flight along them does not require excessive navigational skill on the part of pilots. Additionally, they should not put the aircraft into a state that approaches its minimum safe operation with regard to speed and/or changes of direction, nor should they lie beyond the operating parameters of automated aircraft operating systems.
- 3.5 **Nothing in noise abatement procedures shall prevent the pilot in command from exercising his authority for the safe operation of the aircraft.**
- 3.6 The following procedure design requirements shall be applied in establishing the nominal ground track of NPRs:
- a) Turns during the take-off and climb, solely for noise abatement purposes, shall not be required unless:
 - i) The aeroplane has passed beyond DER².
 - ii) The aeroplane has reached 500 ft aal before commencing the turn and can maintain the prescribed MOC of 90 m (295 ft) or more throughout the turn.
 - iii) The bank angle for turns after take-off is initially limited to 20°, except where adequate provision is made for an acceleration phase permitting the attainment of safe speeds for bank angles greater than 20°.³
 - b) No turns shall be required coincident with a reduction of power associated with a noise abatement procedure;
 - c) Sufficient navigational guidance shall be provided to enable aeroplanes to adhere to the designated route;
 - d) Speeds or aircraft configurations used in determining the nominal ground track shall not be made mandatory.
- 3.7 In establishing NPRs, the safety criteria related to obstacle clearance climb gradients, track guidance, flight technical tolerances and other factors⁴ shall be taken into full consideration.
- 3.8 Noise abatement procedures, including NPRs, shall specify the altitude/height above which they are no longer applicable.
- 3.9 Aircraft should not be diverted from assigned NPRs unless:
- a) The altitude or height which represents the upper limit of the noise abatement procedure/route has been attained (this should be specified in the unit *MATS Part 2* and the appropriate aerodrome AIP entry as the minimum altitude at which tactical radar vectoring is permitted) or,

1. ICAO Doc 8168 *PANS-OPS Volume 1*, Part 1, Section 7.

2. The UK interpretation of DER is the departure end of the runway, i.e. Take-Off Run Available (TORA). See Chapter 5, paragraph 2.

3. See Chapter 5, paragraph 5.6.

4. As described in Chapter 5.

- b) It is necessary for the safety of the aeroplane (e.g. to avoid severe weather or to resolve a traffic conflict).

4 Track Keeping

- 4.1 An important element of the establishment of NPRs is the aerodrome operator's objective for aircraft to adhere as closely as possible to the desired ground track.
- 4.2 It is important to emphasise that the procedure design process establishes a **nominal** ground track for the procedure, and that aircraft in the air cannot adhere to these with the absolute accuracy that may be expected or desired by certain interests on the ground. The ability of an aircraft to adhere closely to the nominal NPR ground track is dependent upon fixed and variable factors, such as:
 - a) route complexity, in particular the extent and design of turns;
 - b) navigational infrastructure, in particular the distance from the navigation aids defining the route;
 - c) aircraft navigational equipment and capabilities;
 - d) aircraft weight and configuration;
 - e) aircraft flight manual requirements;
 - f) aircraft speed and altitude;
 - g) atmospheric conditions acting upon the aircraft.
- 4.3 Punitive measures should not be applied against aircraft that do not achieve the nominal ground track of the NPR as a result of not achieving 500 ft aal by the nominal turn point.
- 4.4 Aerodrome operators must acknowledge that new generations of aircraft (particularly larger or heavier aircraft) may not have the flexibility of operation of earlier generations of aircraft and may be physically incapable of adhering to the nominal ground tracks of NPRs designed for earlier aircraft. It is therefore incumbent upon aerodrome operators to keep the track-keeping performance of aircraft under review.
- 4.5 Aerodrome operators shall obtain in writing confirmation from affected aircraft operators that new or revised NPRs are 'flyable' prior to promulgation. This assurance can be gained from flying the procedures in a flight simulator and should be accompanied by a report from a senior flight operations officer or flight crew.¹

5 Departure Swathe

- 5.1 A degree of divergence either side of the nominal track is expected and in order to assess the environmental impact, aerodrome operators should define a swathe on either side of the nominal ground track within which it is considered reasonable for aircraft to be contained during the course of routine operations.
- 5.2 Responsibility for specifying the noise abatement procedures for London Heathrow, London Gatwick and London Stansted airports² rests directly with the Secretary of State for Transport. For these aerodromes, advice to the public indicating where direct overflight by departing aircraft can normally be expected is expressed in the form of swathes extending 1.5 km either side of the nominal NPR centreline, with a

1. See also Chapter 7.

2. Designated under Section 38 of the Civil Aviation Act 1982.

20° 'funnel' leading from the runway, up to a specified altitude.¹ Other UK aerodrome operators have voluntarily chosen to adopt the same swathe dimensions as 'best practice'.

- 5.3 The departure swathe provides an indication to the public of areas that will be overflown by departing aircraft, but is not intended to indicate an absolute assurance that other areas will **not** be overflown. Similarly, the application of the swathe extends only until an aircraft has reached the specified upper limit of the NPR². Thus aircraft climbing quickly to this upper limit may be subject to tactical ATS intervention and routine radar vectoring beyond the lateral boundaries of the swathe sooner than those that climb more slowly.
- 5.4 In assessing the extent of this swathe it must be borne in mind that procedure containment areas derived through the application of procedure design criteria represent the **flight safety** requirement and the combination of worst-case parameters for potential deviation from the specified nominal track. This, therefore, may differ considerably from the noise swathe and the different objectives associated with both must not be confused.
- 5.5 The general spread of achieved/achievable tracks from a noise abatement perspective (i.e. the nominal NPR swathe) should not extend beyond the limits of the procedure containment areas. However, track-keeping performance standards for noise abatement purposes have not been specified either by ICAO or the UK, and aerodrome operators must take this into account when considering the introduction of track-keeping regimes and must recognise the possibility of aircraft operating legitimately, but exceptionally, to the limits of procedure containment areas (i.e. outside the nominal NPR swathe).
- 5.6 A further factor to be considered by aerodrome operators is the improvement in track repeatability achieved by modern aircraft navigation systems, particularly in the context of RNAV operating concepts. Whilst the day-to-day dispersion of achieved tracks either side of the nominal track may be reducing, one effect of this may be an undesirable over-concentration of ground disturbance.
- 5.7 NPRs are to be subject to periodic review by aerodrome operators to ensure that the nominal NPR ground track and associated swathes continue to meet noise abatement requirements and reflect aircraft capabilities. Such reviews may reveal the need to revise NPRs in the light of changing environmental and operational circumstances.
- 5.8 Aerodrome operators must also acknowledge that where new NPRs are introduced (e.g. from new or extended runways) it may not be possible to accurately determine the achievable nominal ground track of the procedures, and the extent of the swathe, until a period of observation of actual traffic data is available. Procedures may need to be adjusted in the light of operational experience.

6 Promulgation

See Chapter 9.

1. See 'Guidance to the CAA on Environmental Objectives Relating to the Exercise of its Air Navigation Functions', DfT.
2. Paragraphs 3.8 and 3.9 refer.

Chapter 7 Validation of Procedures

1 Requirement

- 1.1 Validation is the final step in the procedure design process, prior to the submission of proposals to the CAA. The purpose of validation is to confirm the correctness and completeness of all obstacle and navigation data, and to assess the flyability of a procedure.
- 1.2 The CAA requires procedure sponsors to undertake validation in accordance with the procedures detailed in *CAP 785 Regulation of the Design of Instrument Flight Procedures for use in UK Airspace* and CAA Policy Statement *Validation of Instrument Flight Procedures*.

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Chapter 8 Departure Procedures and the Airspace Change Process

1 Introduction

- 1.1 Any formal proposal for a new notified departure procedure, or changes to an existing procedure, may require an ACP to be submitted in accordance with the CAA's Airspace Change Process.
- 1.2 A notified departure procedure is a route notified in the *UK AIP* and includes SIDs, CTR Entry/Exit Routes and NPRs within controlled airspace. Omnidirectional procedures would also fall into this category were they to be introduced into UK airspace at some point in the future.
- 1.3 Whilst this document is concerned with the development of instrument departure procedures, the development of new procedures (or the modification of existing procedures) may also require changes to controlled airspace boundaries. Procedure sponsors should, therefore, also be aware of the process to be followed in order to implement changes to controlled airspace boundaries or other changes to the airspace arrangements.

2 The Airspace Change Process

- 2.1 The CAA's *Airspace Charter*¹ details the UK requirements for the development of airspace arrangements (i.e. the Airspace Change Process), the airspace safety management process and the procedures applicants for changes to the airspace arrangements must follow. Supporting guidance on the Airspace Change Process is published separately.² CAA documents are available on the CAA website, www.caa.co.uk.
- 2.2 Changes to airspace arrangements, as laid down in Ministerial Directions, encompass both changes to the airspace boundaries themselves and changes to the procedures contained within controlled airspace.
- 2.3 Fundamental to the airspace change process is the National Air Traffic Management Advisory Committee (NATMAC), which forms the ultimate consultative body on airspace change proposals.

3 Changes to Procedures

- 3.1 Whenever possible, changes to, or the establishment of new, departure procedures should be accommodated within existing controlled airspace boundaries.
- 3.2 The sponsor of a change is to follow the process as detailed in *CAPs 724* and *725*. Proposals submitted to DAP must demonstrate that the sponsor has addressed all procedure design, safety management and environmental consultation matters for the new or modified procedure.
- 3.3 Where a new or modified procedure affects the level or distribution of noise in the vicinity of an aerodrome, the sponsor must ensure that the Airport Consultative

1. *CAP 724 Airspace Charter.*

2. *CAP 725 CAA Guidance on the Application of the Airspace Change Process.*

Committee (where established) and also any local planning authorities whose areas may experience the effects of the procedure, are fully consulted on the effects of the change. This is particularly important where new areas may be overflowed for the first time. An assessment of the likely environmental effects of the change, together with evidence of consultation, forms an integral part of the proposal as submitted to DAP. Other options considered in the evolution of the change proposal, and the extent to which they were considered, must also be documented.

- 3.4 This assessment must also include a study of population numbers likely to be affected by overflight. Additionally, the numbers of aircraft likely to fly the route (traffic density) and the altitudes that overflying aircraft are expected to achieve at various points along the route must also be included in the environmental assessment.
- 3.5 Change sponsors are to refer to the UK DfT's¹ environmental guidance in determining the scope of the environmental assessment and consultation that must be carried out before submitting change proposals to DAP.
- 3.6 Where a proposed change to the airspace arrangements is judged as having a significantly detrimental effect on the environment, DAP is required to advise the Secretary of State of the likely impact and of the steps that the sponsor has taken to mitigate the impact. The Secretary of State must approve such procedures before DAP can implement them.

1. Guidance to the Civil Aviation Authority on Environmental Objectives Relating to the Exercise of its Air Navigation Functions.

Chapter 9 Promulgation of Procedures

1 Promulgation of Departure Procedures

Details of any required departure procedures are to be notified within the relevant Aerodrome (AD 2) pages of the *UK AIP* as follows:

- a) General procedures are to be described in textual format within AD 2.20 – Local Traffic Regulations.
- b) Details of NPRs are to be included in AD 2.21 – Noise Abatement Procedures and unit MATS Pt 2. Such details are to include the altitude/level above which such procedures are no longer applicable.
- c) Specific departure procedures, including references to any SIDs or omnidirectional departures, are to be described at AD 2.22 – Flight Procedures.
- d) Charts depicting generic departure procedures, including NPRs, may be published at AD 2-EGxx-3-1, etc. Such charts may depict NPRs in a general manner, or identify the initial segments of any designated SIDs and/or omnidirectional departures.
- e) Individual charts depicting specific omnidirectional departures and SIDs are to be published at AD 2-EGxx-6-1, etc.
- f) Where departure procedures are limited to specific aircraft categories, the applicability of such procedures must be clearly stated on procedure charts.

2 Chart Detail

- 2.1 Generic charting requirements for departure procedures (including Area Minimum Altitudes) are detailed in *ICAO Annex 4*¹ and *ICAO PANS-OPS*².
- 2.2 In the *UK AIP* a warning placard is included in the graphics section of the Chart to alert pilots where a “stepped climb” (i.e. a procedure with intermediate level segments) is necessary where procedures from adjacent airports interact with each other. This is intended to assist in the alleviation of “level bust” incidents.

3 Additional RNAV Procedure Requirements

- 3.1 Additional requirements for RNAV procedures are detailed in *PANS-OPS*³ and Eurocontrol RNAV procedure design guidance material⁴.
- 3.2 Experience has highlighted the need for clear and unambiguous RNAV procedure descriptions and charts to be published in AIPs, in order that commercial navigation database providers can accurately code the procedures without misinterpretation or error. An unclear or ambiguous procedure description may result in database providers interpreting and coding the procedure in a manner different to that intended, with the result that aircraft may fly on widely differing profiles.

1. *ICAO Annex 4*, in particular Chapter 9 and Appendix 6.

2. *ICAO Doc 8168 PANS-OPS Volume II*, Part I, Section 3, Chapter 5.

3. *ICAO PANS-OPS Volume I*, Part II and *Volume II*, Part III.

4. Eurocontrol *Guidance Material for the Design of Terminal Procedures for Area Navigation (DME/DME, B-GNSS, Baro-VNAV & RNP-RNAV)*, Chapter 11.

- 3.3 Each SID must be described in the following formats:
- textural description;
 - tabular description; and
 - graphical description.
- 3.4 Where a procedure designer requires a particular track to be flown (TF path terminator), or a particular course to be flown (CF path terminator), or a track direct to the next waypoint (DF path terminator) or a particular radius of turn (RF path terminator), this must be clear to the database coder. This can be achieved by a formal textural description **and** an abbreviated procedure description, as detailed in Tables 1 and 2 respectively, and also by including path terminator and waypoint descriptions in a tabular format as illustrated in Table 3.
- 3.5 The use of the abbreviated description on charts is optional, although pilots have indicated that it is a useful quick reference as to the intent of the procedure.

Table 2 Example of P-RNAV Procedure Descriptions (Charting)

Textural Description in AIP	Abbreviated Description	Expected Path Terminator	Flyover Required
Climb on track 074M, at or above 800 ft turn right.	[A800+;M047;R]	FA	N
Climb on heading 123M, at or above 1,000 ft turn right.	[A1000+;M123;R]	VA	N
Direct to ARDAG at 3,000 ft	ARDAG[A3000]	DF	N
To <u>PEW07</u> at or below 2,000 ft, left turn.	<u>PEW07</u> [A2000-;L]	TF	Y
To OTR on course 090M at 210 kt.	OTR[M090;K210]	CF	N
To <u>DFE36</u> at 2,000 ft minimum, 4,000 ft maximum, minimum speed 210 kt.	<u>DFE36</u> [A2000+; A4000-;K210-]	TF	Y

Table 3 Coding Standard for Abbreviated RNAV Procedure Description

An RNAV procedure is defined by a number of waypoints, each defined by a waypoint name and a set of constraints.	
<u>Waypoint Name</u> (underlined)	denotes "flyover";
Waypoint Name (not underlined)	denotes "flyby";
"To" Waypoint Name	denotes TF leg coding;
"Direct to" Waypoint Name	denotes DF leg coding;
"Climb on track xxx"	denotes CA leg coding;
"To" Waypoint Name "on track xxx"	denotes CF leg coding;
"Climb on heading xxx"	denotes VA leg coding (only used for parallel runway departures);
"From (Waypoint Name) to (Altitude/Flight Level) on track xxx"	denotes FA leg coding;
Waypoint name followed by {R, NN.N, Lat/Long}	denotes the waypoint at the end of a turn, the radius and the centre-point of a fixed radius turn;
Speed, track and level constraints are contained within square brackets [.....]	
If [a set of constraints] is not preceded by a waypoint name then the last calculated track must be flown until the constraint is reached.	
<p>Each constraint is coded in the format "UNNNNNCD" where:</p> <ul style="list-style-type: none"> U may be one of the following: <ul style="list-style-type: none"> A for altitude in ft above mean sea level (AMSL); F for Flight Level; K for Indicated Air speed in knots; M for degrees Magnetic; T for degrees True. NNNNN is a number from 000 to 99999 C may be one of the following: <ul style="list-style-type: none"> + for "at or above"; - for "at or below"; a blank space for "at". D is used to indicate direction of turn in conditional and flyover waypoints. 	
<p>Multiple constraints at a waypoint are separated by a semi-colon (;)</p> <p>Individual waypoints in a procedure, together with their associated constraints, should be separated by a hyphen (-) except where the subsequent leg is coded as a DF leg when an arrow (→) should be used.</p>	

Table 4 Example of P-RNAV SID Path Terminator and Waypoint Descriptions (Charting)

SID Designator	Sequence Number	Path Terminator	Waypoint Name	Co-ordinates DD MM SS.ss DDD MM SS.ss	Course/ Track °T (°M)	Turn Direction	Level Constraint (ALT)	Speed Constraint (kt)	Distance from DER (NM)
CSR 2Z	001	-	Rwy 27	52 24'36.0"N 001 00'50.0"W	271.4 (274)	-	-	-	-
CSR 2Z	002	TF	KNS02	52 27'19.8"N 000 59'38.8"W	220.2 (223)	L	1200+	210-	2.2
CSR 2Z	003	TF	KNS02	51 27'19.8"N 000 59'38.8"W	200.6 (203)	L	3000+	210-	4.7
CSR 2Z	004	TF	KNW08	52 27'19.8"N 000 60'38.8"W	245.3 (248)	R	4000+	250-	8.3
CSR 2Z	005	TF	KNS12	51 27'19.8"N 000 61'38.8"W	240.7 (243)	L	5000-	250-	12.6
CSR 2Z	006	TF	KNW32	52 27'19.8"N 000 62'38.8"W	259.5 (262)	R	6000+	250-	32.4
CSR 2Z	007	TF	CSR VOR	53 27'19.8"N 000 64'38.8"W	-	-	6000+	250-	47.5

Appendix A Source and Reference Documents

1.1 The procedure design and consultation requirements detailed in this document are compatible with the requirements specified in *CAP 724 Airspace Charter*.

1.2 Source documents from which UK departure procedure policy is derived include:

ICAO

Annex 4 Charting

Annex 11 Air Traffic Services

Annex 15 Aeronautical Information Services

Annex 16 Environmental Protection

Doc 8168 Procedures for Air Navigation Services – Operations (PANS-OPS)
Volume 1 – Flight Procedures

Doc 8168 Procedures for Air Navigation Services – Operations (PANS-OPS)
Volume 2 – Construction of Instrument and Visual Flight Procedures
(includes Ground and Flight Validation)

Doc 8071 Manual on Testing of Radio Navigational Aids Volume 1

Doc 4444 Procedures for Air Navigation Services – Air Traffic Management (PANS-ATM)

Doc 9368 Instrument Flight Procedures Construction Manual

Doc 9426 ATS Planning Manual

JAA/EASA

Temporary Guidance Leaflet 10 (TGL10) - Airworthiness and Operational Approval for Precision RNAV Operations in Designated European Airspace

Eurocontrol

Navigation Application and Navigation Aid Infrastructure Strategy for the ECAC Area up to 2020, Edition 2 (May 2008)

Operational Requirement for RNAV Applications in Terminal Airspace

Guidance Material for the Design of Terminal Procedures for DME/DME and GNSS Area Navigation (NAV. ET1. ST10)

Charting Guidelines for RNAV Procedures

Guidance Material for the Flight Inspection of RNAV Procedures

Strategic Guidance in Support of the Execution of the European ATM Master Plan (30 March 2009)

Department for Transport

Transport Act 2000

Secretary of State's Directions to the Civil Aviation Authority

Guidance to the Civil Aviation Authority on Environmental Objectives Relating to the Exercise of its Air Navigation Functions

CAA

CAP 724 Airspace Charter

CAP 725 Guidance on the Application of the Airspace Change Process

CAP 785 Regulation of the Design of Instrument Flight Procedures for use in UK Airspace

Safety Buffer Policy For Airspace Design Purposes – Segregated Airspace (Directorate of Airspace Policy, January 2007)

Use and Allocation of RNAV Waypoints (Directorate of Airspace Policy, October 2008)
Validation of Instrument Flight Procedures (Directorate of Airspace Policy, June 2009)

- 1.3 Other useful documents, whilst not part of the UK design standard, include:
- a) RTCA *DO-201A* / EUROCAE *ED77 Standards for Aeronautical Information*; and
 - b) RTCA / EUROCAE *ED75B Minimum Aircraft System Performance Standards (MASPS): Required Navigation Performance for Area Navigation*
- 1.4 In general the UK has adopted the principles and criteria detailed in ICAO *Doc 8168 PANS-OPS* as meeting the safety requirement. However, these are modified or amplified to meet specific UK requirements. Specific UK Differences from the *PANS-OPS* criteria are notified in the *UK AIP*.
- 1.5 Procedure designers are to refer to the source documents (together with the *UK AIP* for notified Differences) for the detailed criteria to be used when designing instrument departure procedures, particularly in respect of obstacle clearance requirements and across track tolerance requirements.