CIVIL AVIATION PUBLICATION

CAP 11

AREA NAVIGATION (RNAV)

INDEX

This Page Intentionally Left Blank

CIVIL AVIATION PUBLICATIONS

CAP 11

AREA NAVIGATION (RNAV)

INDEX

This Page Intentionally Left Blank

1. INTRODUCTION

1.1 Purpose

The purpose of this CAP is to provide guidance to AOC/Private Authorisation holders on generic training, operational issues and operational approval requirements for area navigation (RNAV) operations and similar Flight Management Systems (FMS) managed navigation procedures. As there have been, and will be changes in the near future, the objective of this CAP is to provide a clear statement on the requirements and terminology related to RNAV.

Note 1: *Refer to CAP 12 for specific B-RNAV requirements and application procedure.*

Note 2: *Refer to CAP 13 for specific P-RNAV requirements and application procedure.*

Note 3: *Refer to CAP 14 for specific RNP AR requirements and application procedure.*

Note 4: *Refer to CAP 15 for specific RNP APCH requirements and application procedure*

1.2 Glossary of Terms

The following is an explanation of some of the terms used in RNAV procedures. Where possible the ICAO (or the most widely accepted) explanations have been used. It is recognised that the proliferation of terms is a safety concern and the CAA is supporting efforts to rationalise and harmonise the terms in use. Some of the terms in use below may therefore be subject to change and may be considered superfluous. Nevertheless, it is felt important to identify as many as possible to help clear up confusion.

Aircraft-Based Augmentation System (ABAS). An augmentation system that augments and/or integrates the information obtained from GNSS elements with all the other information available on board the aircraft.

Airspace Concept. An Airspace Concept provides the outline and intended framework of operations within an airspace. An Airspace Concept is essentially a high-level statement of an airspace plan. Airspace Concepts are developed to satisfy explicit strategic objectives such as improved safety, increased air traffic capacity and mitigation of environmental impact. Airspace Concepts include details of the practical organisation of the airspace and its users based on particular CNS/ATM assumptions, e.g. ATS route structure, separation minima, route spacing and obstacle clearance.

Approach procedure with vertical guidance (APV). An instrument procedure, which utilises lateral and vertical guidance, but does not meet the requirements established for precision approach and landing operations.

Area navigation (RNAV). A method of navigation which permits aircraft operation on any desired flight path within the coverage of station-referenced navigation aids or within the limits of the capability of self-contained aids, or a combination of these.

Note: Area navigation includes performance based navigation as well as other RNAV operations that do not meet the definition of performance based navigation.

Area navigation route. An ATS route established for the use of aircraft capable of employing area navigation.

B-RNAV. A European RNAV navigation specification with a required track keeping accuracy of ±5 NM for at least 95% of the flight time. B-RNAV or Basic RNAV capability can be achieved using inputs from VOR/DME, DME/DME or GNSS and/or INS.

Critical DME. A DME facility that, when unavailable, results in a navigation service which is insufficient for DME/DME or DME/DME/IRU based operations along a specific route or procedure. These services are defined based on the minimum charted requirements for that procedure.

EGNOS. European Geostationary Navigation Overlay Service. A European version of Satellite Based Augmentation System. It uses a network of ground stations over the whole of Europe which continually analyse the satellite signals from GPS, GLONASS and Galileo. From this analysis, correction and integrity signals are sent to geostationary (INMARSAT) satellites and then rebroadcast for navigation satellite system users to apply. It should be noted that SBAS enabled GNSS receivers are needed in order to use EGNOS correction signals.

Letter of Acceptance (LOA)

(a) Type 1 LOA - Letter of acceptance granted where a navigation database supplier complies with EUROCAE ED-76/RTCA DO-200A documents with no identified compatibility with an aircraft system. A Type 1 LOA confirms that the processes for producing navigation data comply with these conditions and the documented Data Quality Requirements. A Type 1 LOA holder may not release navigation databases directly to end users.

(b) Type 2 LOA - Letter of acceptance granted where a navigation database supplier complies with EUROCAE ED-76/RTCA DO-200A documents and provides data compatible with specified avionics systems. A Type 2 LOA confirms that the processes for producing navigation data comply with these conditions and the documented Data Quality Requirements for the avionics systems specified. The Data Quality Requirements must be provided by or agreed with the specified equipment design organisation in accordance with a formal arrangement. A Type 2 LOA holder may release navigation databases directly to end users. Such releases may also include data packing tools, where the use of such tools has been demonstrated to be ED-76/DO-200A compliant. A Type 2 LOA holder may interface directly with data originators (such as State AIP providers and operators), or may use data supplied by a Type 1 LOA holder in which case interfaces with data originators may not be necessary.

Localizer Performance with Vertical Guidance (LPV). A US term for an augmented GNSS approach utilising geometric vertical navigation with the following FAA definition. A type of approach with vertical guidance (APV) based on WAAS, published on RNAV (GPS) approach charts. This procedure takes advantage of the more precise lateral guidance

available from WAAS enabled GNSS receivers. The approach minimum is published as a decision altitude (DA).

Navigation Aid Infrastructure. Navigation aid infrastructure refers to space-based and/or ground-based navigation aids available to meet the requirements in the navigation specification.

Navigation Application. The application of a navigation specification and the supporting navigation aid infrastructure to routes, procedures and/or defined airspace volume, in accordance with the intended airspace concept.

Note: The navigation application is one element, along with communication, surveillance and ATM procedures, meeting the strategic objectives in a defined airspace concept.

Navigation Function. The detailed capability of the navigation system (such as the execution of leg transitions, parallel offset capabilities, holding patterns and navigation databases) required to meet the Airspace Concept.

Note: Navigational functional requirements are one of the drivers for selection of a particular navigation specification.

Navigation Specification. A navigation specification is a set of aircraft and flight crew requirements needed to support Performance Based Navigation operations within a defined airspace. There are two kinds of navigation specification:

(a) RNAV X. A navigation specification designation that does not include requirement for on-board performance monitoring and alerting.

(b) RNP X. A navigation specification designation that includes requirements for on-board performance monitoring and alerting.

Note: For both RNP X and RNAV X, the expression 'X' refers to the lateral navigation accuracy in nautical miles that is expected to be achieved at least 95 per cent of the flight time.

Overlays. The use of RNAV systems to fly instrument flight procedures that are themselves based on conventional ground navigational aids and can be flown without the use of an RNAV system.

Pseudorange. A term used to describe the complex signals transmitted by GNSS satellite vehicles, which contain both range and additional information from each satellite vehicle in view to a receiver. Once processed by the GNSS receiver, ranges from each satellite vehicle are extracted enabling an accurate position to be determined. In addition, this processing also extracts accurate time.

Performance Based Navigation. Performance Based Navigation specifies system performance requirements for aircraft operating along an ATS route, on an instrument approach procedure or in an airspace block. Performance requirements are defined in terms of the accuracy, integrity, continuity, availability and functionality needed for the proposed operation in the context of a particular airspace concept.

P-RNAV. A European RNAV navigation specification with a required track-keeping accuracy of ±1 NM for at least 95% of the flight time, together with advanced functionality and a high integrity navigation database. P-RNAV capability can be achieved using inputs from DME/DME or GNSS and/or INS.

Receiver Autonomous Integrity Monitoring (RAIM). A technique whereby a GNSS receiver processor determines the integrity of the GNSS navigation signals using only GPS signals or GPS signals and altitude. This determination is achieved by a consistency check against additional satellite vehicle pseudorange or altitude measurements. Additional, in this context, means more satellite vehicles in view than are needed for position calculation; i.e. for a 2-D position, a minimum of three satellites need to be in view of the receiver; a 3-D solution requires a minimum of four satellites.

RNAV 1 SID/STAR (FAA Operations). Procedures requiring system performance currently met by GPS or DME/DME/IRU RNAV systems satisfying the criteria discussed in FAA AC 90-100A. RNAV 1 procedures may require the aircraft's track-keeping accuracy remain bounded by ±1 NM for 95% of the total flight time.

RNAV 2 SID/STAR (FAA Operations). RNAV terminal procedures requiring system performance currently met by GPS or DME/DME/IRU RNAV systems satisfying the criteria discussed in FAA AC 90-100A. RNAV 2 terminal procedures require the aircraft's track-keeping accuracy remain bounded by ±2 NM for 95% of the total flight time.

RNAV (GNSS). Approach operations. Basic approach operations in designated European airspace. Initially designed as 2-D RNAV (GNSS) with no vertical guidance, i.e. non-precision. EASA AMC development is expected to expand the utilisation of the Aircraft VNAV function for vertical guidance. Baro-VNAV approach procedures are to be classified by ICAO as APV. Referred to as RNP APCH in the draft ICAO PBN Manual as the application requires on-board performance monitoring and alerting. For charting purposes will remain as RNAV (GNSS).

RNAV Operations. Aircraft operations using an area navigation system for RNAV applications. RNAV operations include the use of area navigation for operations which are not developed in accordance with the PBN Manual.

RNAV System. A navigation system which permits aircraft operation on any desired flight path within the coverage of station-referenced navigation aids or within the limits of the capability of self-contained aids, or a combination of these. An RNAV system may be included as part of a Flight Management System (FMS).

RNP AR APCH. RNP Authorisation Required Approaches represent the ICAO equivalent to FAA RNP Special Aircraft and Aircrew Authorization Required (SAAAR) operations.

RNP System. An area navigation system which supports on-board performance monitoring and alerting.

RNP Operations. Aircraft operations using an RNP System for RNP applications.

Note: Some flight management systems use the term RNP as either a containment value or measure of likely system navigation performance. This rather loose use of "RNP" is a source of confusion.

Satellite Based Augmentation System (SBAS). A wide area coverage augmentation system for satellite navigation systems (GPS, GLONASS, Galileo). An SBAS requires a network of ground stations across the area of augmentation and one or more geostationary satellites able to broadcast signals over this area. The ground stations continually monitor the signals from the satellite navigation system of interest, and from an analysis of the signals integrity information and accuracy corrections can be provided for the whole of the augmentation area. The correction signals are sent from a ground master station to the geostationary satellite and re-broadcast. Few aeronautical standard receivers are currently configured to receive SBAS signals. The United States SBAS is known by the acronym WAAS whilst the Europeans have EGNOS, with the Japanese developing MSAS (Multi-functional Satellite Augmentation System).

Vertical Navigation (VNAV). A method of navigation which permits aircraft operation on a vertical flight profile using altimetry sources, external flight path references, or a combination of these.

Wide-Area Augmentation System (WAAS). This is the term for the US satellite based augmentation system (SBAS) which augments the GPS Standard Positioning Service (SPS). It provides enhanced integrity, accuracy, availability and continuity to the SPS over the contiguous United States.

1.3 References

The following references provide information on RNAV:

(a) ICAO Doc. 9613, Performance Based Navigation Manual:

(b) ICAO DOC 8168 Procedures for air navigation services aircraft operations (Volume II) Construction of Visual and Instrument Flight Procedures.

(c) JAA TGL 10 (P-RNAV)

(d) ANTR-OPS 1.243

2. PERFORMANCE BASED NAVIGATION (PBN) CONCEPTS

Over the last 10 to 15 years the regional implementation of RNAV has led to a proliferation of area navigation descriptions, approval requirements and terms. This has resulted in confusion and the International Civil Aviation Organization (ICAO) recognised that the current global guidance material needed to be revised. ICAO has published a PBN Manual and this manual is available at www.icao.int/pbn.

This manual deals comprehensively with all RNAV matters and goes a long way to rectifying existing confusion. Aircraft navigation will for the first time be harmonised globally and a process put in place for the future design of airspace based around RNAV and RNP concepts.

Aircraft navigation has already evolved to the point where realisable benefits can be gained from RNAV in the en-route, terminal airspace and final approach flight phases. The lateral performance available from modern navigation sensors (including GNSS) means that reduced separation and obstacle clearance can bring about increased capacity and greater access. The functionality of RNAV systems, some with built-in performance monitoring and alerting algorithms, enables trajectories with predictable, repeatable path definition to be flown, providing environmental relief (reduced noise and emissions) together with fuel savings from direct routeings.

In the longer term, there is likely to be an increased dependence upon advanced RNAV operations. With the continuing growth in traffic and the need to mitigate environmental impact to the greatest extent possible, RNAV, together with a transition to a GNSS-based navigation environment, is key to delivering the benefits being sought. The capability of aircraft navigation systems will evolve to meet new and developing requirements. RNP is seen as the likely enabler in the future European Air Traffic Management (ATM) concept and work is already under way to identify functional and operational requirements for both airborne systems and air traffic control system tools necessary to support this future. Within European terminal airspace, the goals for 2020+ include evolving from today's arrival and departure procedures which just specify a lateral (2-D) accuracy requirement to a system of navigation having vertical performance (3-D) and eventually Required Time of Arrival (4-D) performance.

In parallel with airborne systems development, the Air Navigation Service Providers (ANSP) and their regulators are looking at the infrastructure necessary to support future ATM concepts. Further rationalisation of the traditional ground-based navigation infrastructure is anticipated, leading to a navigation architecture based on GPS and Galileo GNSS constellations with Distance Measuring Equipment (DME) as a back-up.

At the international level, as new navigation specifications are developed they will be ratified by ICAO and then included within the PBN Manual enabling adoption as world-wide, harmonised standards.

3. OPERATIONAL APPROVAL REQUIREMENTS FOR RNAV OPERATIONS

It is not always apparent to airspace users how navigation specifications fit into the overall safe and efficient use of the airspace. In particular, attention is often focused on the aircraft system accuracy requirements, whereas for the ANSP the separation standards, integrity of navigation and repeatability of adherence to the flight paths can be an equally important part of the overall safety management of the airspace. The granting of an approval to an operator provides an assurance to the Air Navigation Service Providers that all of the navigation concept assumptions of accuracy, integrity and interoperability are met. Consequently, it may be necessary to provide additional training and oversight to meet the required level of assurance.

The operator will need to demonstrate that they have robust training and procedures in place to ensure compliance with the navigation specification (e.g. P-RNAV, B-RNAV, RNP, etc.). This may require a demonstration or trial in the simulator or aircraft to the satisfaction of the assigned Aircraft Operations Inspector.

4. AIRCRAFT ELIGIBILITY

The on-board RNAV systems must be fit for the intended purpose. Operators must be satisfied that a particular operation is supported by an airworthiness approval reflected in the flight manual or other approved manufacturer's documentation, such as flight crew operating manual or pilot operating handbook. When approving an operator for any new RNAV operation the CAA will need to be shown the evidence of airworthiness suitability.

5. SPECIFIC APPROVAL PROCESSES

Below is a brief summary of the approval requirements for specific RNAV Navigation Specifications/RNAV applications:

5.1 European Basic RNAV (B-RNAV)

Approval is required under ANTR-OPS 1/3.243, conferred by an entry in the Operations Specification. Procedures and a training syllabus must be included in the operations manual and have been accepted by the assigned Inspector.

Note: Refer to CAP 12 for B-RNAV requirements and application procedure.

5.2 European Precision RNAV (P-RNAV)

Approval is required ANTR-OPS 1/3.243, conferred by an entry in the Operations Specification (AOC holders only).

Note: Refer to CAP 13 for P-RNAV requirements and application procedure.

5.3 Overlay non-precision approaches

Use of RNAV systems to fly conventional non-precision approaches i.e. overlays of conventional non-precision approaches and overlays of Standard Instrument Departures (SID) and Standard Arrivals (STARS) Prior to commencing these operations, the assigned CAA Inspector must have signified acceptance of relevant procedures and training specified in the operations manual.

5.4 RNAV (GNSS) approach operations

Prior to commencing RNAV (GNSS) approach operations, a submission shall be made to the CAA through the assigned Inspector. This submission should detail the changes to operational procedures, operations manual entries, Minimum Equipment List (MEL) and the training syllabus, together with a plan for identification of hazards and the management of the risks associated with the introduction of the new approach type. The Operations Specification will be annotated to include RNAV (GNSS) final approach.

5.5 RNP Authorisation Required (RNP AR)

These procedures are designed for RNAV systems with Required Navigation Performance (RNP) capability. Flight crews operating on these procedures will require additional training over and above that required for RNAV (GNSS).

In the United States these procedures are referred to as Special Aircraft and Aircrew Authorisation Required (SAAAR) (see FAA AC 90-101). The Operations Specification will be annotated to include RNP AR.

6. IMPLEMENTATION CONSIDERATIONS

When producing documents and procedures to support the introduction of an RNAV operation the following list may prove useful to an operator. The list is not exhaustive and the CAPs addressing the specific type of operation expand on this list.

- Introduction – examining the application of differing navigation procedures.
- Definitions – an explanation of RNAV terms, relating them to the standard terms (see Appendix B), and how they are used as part of the operating procedures.
- Hazard analysis leading to a plan for the management of risks associated with the introduction of the new navigation procedures.
- Aircraft installation – overview of the systems incorporated within the aircraft.
- Aircraft navigation – explanation of the aircraft navigation systems.
- GPS/FMS – general overview of the on-board navigation system and satellite constellation (if used) or general reference to aircraft systems for maintaining accuracy. Where applicable, implications of the availability of the satellite navigation constellation on navigation accuracy should be detailed.
- MEL – dispatch requirements and the effects on navigation due to system failures.
- Navigation database production – requirements for Letter of Acceptance from database supplier and quality assurance requirements.
- Feedback procedures for reporting RNAV deficiencies to the operator's department responsible for navigation database and, if appropriate, onwards transmission to database supplier.
- RNAV procedures – Manufacturer's Standard Operating Procedures (SOPs) or approved operator defined procedures.
- Briefing of the procedure prior to commencement – particularly important with respect to approach operations.
- Charting/FMS database consistency – procedures to detect potential discrepancies.
- ATC and R/T phraseology – introduction to the ATC environment and R/T procedures (see ICAO Doc 7030 Regional Supplementary Procedures).
- Abnormal procedures – contingency identification and actions to be taken.
- Procedures for the application of RNAV aerodrome operating minima.

- Flight crew training – training requirements for all types of RNAV operation.

7. NAVIGATION DATABASE

The correct coding of the navigation database is fundamental to all RNAV operations. The use of a coded flight procedure must enable the aircraft to follow the published profile with the required integrity and accuracy without an increase in pilot workload.

Listed below are a number of points to help ensure the adequacy of the navigation database. The list is not exhaustive, nor is it expected that all of the items must be achieved for all RNAV operations. However, where the consequence of the aircraft not adhering to the flight procedure poses a greater risk to the aircraft, such as RNAV final approach, then all five elements should be considered:

- The navigation database should be supplied from an ED-76/DO-200A qualified entity;

- The operator should apply the quality process required by ANTR-OPS 1/3.035 in relation to the navigation database supplier;

- The operator should perform spot checks of the navigation database against the published procedures, concentrating on higher risk elements and changes. Use can be made of software tools;

- RNAV flight procedures, when identified as novel, complex or in close proximity to mountainous terrain, should be flown in the simulator and trialled in the aircraft to ensure that the operator's aircraft can adhere to the procedure;

- There should be a feedback system in place, which includes the database supplier, to ensure that anomalies are reported swiftly and erroneous procedures withdrawn.

Note: Refer also to ANTR-OPS 1 relating to the management of electronic navigation data for all airborne navigation applications.

8. TRAINING

A modular guide for RNAV training can be found at Appendix 1. This guide details the minimum training the CAA considers necessary for generic RNAV procedures and this basic training package would normally be completed along with one other individual module (e.g. B-RNAV etc).

The training in the use of RNAV systems to fly conventional non-precision approaches (NDB, VOR, etc.) referred to as overlay procedures is specified separately at Appendix 2. However, because this method of flying contains elements identical to that of flying an RNAV final approach, credit can be taken when both these operations are trained together, or sequentially.

If credit for training in both of these operations is taken, operators should ensure that, where feasible, procedures for using RNAV equipment to fly conventional non-precision approaches mirror those used for RNAV final approaches.

In addition to specific flight crew training, training packages should emphasise any relevant airspace management issues, e.g. compliance with relevant speed and altitude constraints associated with a procedure. Specific instructions may be necessary for configuration of the aircraft under either manual or automatic control to ensure adherence to the nominal path, e.g. departure procedure turns. Finally, consideration should be given within flight crew SOPs for handling potential last minute runway changes.

APPENDIX 1

BASIC RNAV CONCEPTS TRAINING

TYPE OF OPERATION	TRAINING REQUIRED	TRAINING METHODS	CHECKING and CURRENCY
All RNAV OPERATIONS	Basic RNAV Concepts: • Theory of RNAV including differences between B-RNAV, P-RNAV and RNP-RNAV; • The meaning of RNP/ANP; • Limitations of RNAV; • GPS concepts and limitations (if applicable); • Charting, database and avionics issues including: a) Waypoint naming and depiction concepts; b) Fly-by and Fly-over waypoints; • Use of RNAV equipment including, where appropriate: a) Verification and sensor management; b) Tactically modifying the flight plan; c) Addressing discontinuities; d) Entering associated data such as: i) Wind; ii) Altitude/Speed constraints; iii) Vertical profile/Vertical speed; • R/T phraseology for RNAV; • The implications for RNAV operations of systems malfunctions which are not RNAV related (e.g. hydraulic failure or engine failure).	Some or all of: • Operations Manual content; • Handouts (paper or electronic); • Computer Based Training (CBT); • Classroom.	
Note: Training in Basic RNAV Concepts is required for all types of RNAV operations. However, credit may be given/taken for previous Basic RNAV Concept training when adding a qualification for further type(s) of RNAV operations.			

APPENDIX 2

OVERLAY PROCEDURE TRAINING

TYPE OF OPERATION	TRAINING REQUIRED	TRAINING METHODS	CHECKING and CURRENCY
OVERLAY	• Basic RNAV Concept Training; and training in the following topics: • Definition and concept of overlay procedures; • Limitations on using overlay procedures; • Precedence of raw data; • Display management; • Required navigation equipment for overlay procedures including MEL issues; • Limitations on the use of vertical navigation modes; • Retrieving a conventional approach procedure from the database, briefing the procedure, comparing it with the charted procedure and action to be taken if discrepancies are noted; • Flying the procedure: a) Use of autopilot, autothrottle and flight director; b) AFDS mode behaviour; c) Lateral and vertical path management; d) Adherence to speed and/or altitude constraints; e) The use of other aircraft equipment to support track monitoring, weather and obstacle avoidance; • Contingency procedures; • Missed approach procedures.	Some or all of: • Operations Manual content; • Handouts (paper or electronic); • CBT; • Classroom; and • Flight Simulator Training (FST) including: a) Training to proficiency for each crew member in both PF and PNF roles according to operator procedures; b) Failures such as map shift, sensor failure etc.; c) Go-around from DH and/or an intermediate position.	One approach with system/sensor failure as part of OPC/FST. Failure may be in either P-RNAV arrival or overlay procedure.
Note: Credit may be given/taken for previous Basic RNAV Concept Training when adding a qualification for Overlay Procedure operations.			