CIVIL AVIATION ADVISORY PUBLICATION

CAAP 3

(01 January 2013)

RNP 5 DATA

DATA REQUIREMENTS FOR REQUIRED NAVIGATION PERFORMANCE 5 (RNP 5)

1. PURPOSE

This Civil Aviation Advisory Publication (CAAP) provides guidance to those operators, whose aircraft equipment cannot be readily determined to meet the necessary operational approval for Required Navigation Performance 5 (RNP 5) or better. The procedures detailed in this CAAP enable an operator to determine their capability of meeting the navigation element requirements and to become eligible for approval for operations in areas, when and where RNP is specified. It includes guidance on the data collection requirements (if required) to be assessed for RNP 5 or better. All Yemen operators planning to operate in European upper airspace designated for Basic Area Navigation (B-RNAV) after 01 August, 1998 must meet RNP 5. The RNP 5 approval forms part of the B-RNAV approval contained in CAAP 2, B-RNAV. The approval process for RNP 5 is the same for any level of RNP and, with the exception of B-RNAV, the reference to RNP 5 can apply to other RNP values (eg RNP 4).

This CAAP does not address communications or surveillance requirements that may be specified to operate on a particular route or in a particular area. Those requirements are specified in other documents such as Aeronautical Information Publications (AIP) and the International Civil Aviation Organisation (ICAO) Regional Supplementary Procedures (Doc 7030). There is also CAMA Flight Operations Inspector guidance material required for the reduction and assessment of acquired data.

2. STATUS OF THIS CAAP

This is CAAP 3 issued 01 January 2013. It will remain current until withdrawn or superseded.

3. APPLICABILITY

This guidance material applies to Yemen operators, who wish to operate in RNP airspace or on RNP routes, and cannot determine if their aircraft navigation equipment meet the requirements of CAAP 2. It also applies where the operator chooses to lengthen the RNP time limits. Yemen registered aircraft, when operating within the Yemen FIR must comply with RNP 5 and, outside the Yemen FIR, must comply with ICAO Annex 2 and other States' regulations when operating within their airspace.

The contents of this CAAP does **not** apply to operators of Transport Category aircraft equipped with Flight Management Systems (FMS) with barometric vertical navigation (VNAV) oceanic, en route, terminal and approach capability. They should only refer to CAAP 2. It is a prerequisite that all other equipped aircraft must determine their eligibility, and if required, supply the data in order to be assessed as RNP capable and before an application for B-RNAV (European Airspace) will be processed.

4. CONTENTS

5. BACKGROUND

ICAO Contracting States are beginning to introduce RNP as part of a worldwide ICAO effort to implement the Future Air Navigation Systems (FANS), Communications, Navigation, Surveillance (CNS) and Air Traffic Management (ATM) concept. Reduced separation minima are an integral part of these initiatives.

Through ICAO, the Informal South Pacific Air Traffic Services Coordinating Group (ISPACG) and other fora, new separation minima - 50 NM lateral and 50 NM longitudinal - have been developed for use in oceanic and remote areas. Initially, these new separation minima will be introduced on routes in the North Pacific (NOPAC), Central East Pacific (CEPAC), South Pacific (SOPAC) and Tasman Sea.

RNP 5 separation minima was introduced into Yemen airspace on 01 January, 1999. Due to the relatively small size of Yemen airspace and numerous navigation aids, this requirement should not affect any Yemen operators. However, Yemen international operators of aircraft *not* equipped with Flight Management Systems (FMS) with barometric vertical navigation (VNAV) oceanic, en route, terminal and approach capability, must meet the approval requirements of RNP 5 before an application for B-RNAV (European Airspace) will be processed.

In accordance with ICAO coordinated regional agreements, operators must obtain an RNP 5 approval from the operator's State of Registry or State of the Operator (CAMA) in order to conduct upper level IFR operations in European airspace (after 01 August, 1998), and on specific FANS air routes. The RNP 5 requirement will most likely be adopted as an industry standard in other regions.

The adoption of RNP will provide immediate benefits to operators in terms of more optimum routings, reduced delays, increased flexibility, reduced costs, all with no reduction in safety, together with benefits for service providers by way of a more efficient use of airspace and increased traffic flow.

6. REFERENCES

(a) Civil Aviation Safety Authority (Australia)
  (i) Civil Aviation Advisory Publications 35-1, 35-2, 35-3

(b) Federal Aviation Administration (FAA)
  (i) Federal Aviation Regulations Part 121 Annex G.

(c) International Civil Aviation Organisation (ICAO)
  (i) ICAO Doc 7030/4, MID/ASIA/RAC, PAC/RAC, and EUR/RAC.
  (ii) Manual on Required Navigation Performance (RNP), ICAO DOC 9613- AN/937.

(d) Asia Pacific Guidance Material for RNAV Operations. (Copies may be obtained from Document Sales Unit, ICAO, 999 University Street, Montreal, Quebec, Canada H3C 5H7).

(e) RTCA

(i) Minimum Aviation System Performance Standards (MASPS): Required Navigation Performance for Area Navigation, RTCA. (Copies may be obtained from RTCA, Inc., 1140 Connecticut Avenue, NW, Suite 1020, Washington, DC 20036).

7. OVERVIEW

7.1 Procedure.

The following is guidance to an operator for establishing equipment eligibility and associated data collection. An operator should;

(a) determine if the aircraft navigation equipment already meets the required RNP (refer to para 8. If so, go to CAAP 2, B-RNAV. If not;

(b) determine if the data can be obtained as a "group" or "non group" aircraft (refer to para 9)

(c) arrange a pre-application meeting with the CAMA.

(d) compile the necessary data in accordance with Section 11.

(e) determine if updating is required to increase the time limit and, if so complete the necessary data.

7.2 APPROVED AIRCRAFT/SYSTEM LIST

The CAMA Airworthiness Section will maintain a list of aircraft/navigation systems that have received approval. It will not be used as a means of determining qualifications for approval. The list will be maintained for statistical purposes and will provide information to operators on those aircraft and navigation systems which have been approved. It should be noted that Doppler systems cannot be approved for RNP

8. DETERMINING AIRCRAFT EQUIPMENT ELIGIBILITY

8.1 Introduction.

There are three different ways of determining eligibility of the aircraft equipment; certification, documentation and assessed data. If the Airworthiness documentation cannot provide the necessary evidence, data collection must be conducted.

8.2 Aircraft Eligibility Through RNP Certification.

Aircraft are eligible if they have obtained formal certification and approval of RNP integration in the aircraft.

8.2.1 RNP Compliance

RNP compliance is documented in the AFM, and is typically not limited to RNP 5. The AFM will address RNP levels that have been demonstrated and any related provisions applicable to its use (e.g; navaid sensor requirements). Operational approval will be based upon the performance stated in the AFM.

8.2.2 Airworthiness Approval

An airworthiness approval specifically addressing RNP performance may be obtained. Part of that approval includes an appropriate AFM Supplement, containing the system limitations and having reference to the manufacturer's operating procedures applicable to the equipment installed. Normally the Regulatory Authority of the State of Manufacture or State of the Operator would attest to this performance, however other documentation would be assessed on a case by case basis.

8.3 Aircraft Eligibility Through Prior Navigation System Certification.

Aircraft are eligible if they can equate their certified level of navigation system performance, under previous standards, to the RNP criteria. The standards listed in Sections 8.3.1 to 8.3.5 below can be used to qualify an aircraft. Other standards may also be used if they are sufficient to ensure that the RNP requirements are met. If other standards are to be used, the applicant must propose an acceptable means of compliance. As new standards are used for the basis of RNP, this CAAP will be revised to reflect the new standards.

8.3.1 Transport Category Aircraft With Dual FMSs.

Transport Category aircraft equipped with INSs or IRUs, Radio Navigation Positioning Updating and Electronic Map Displays in accordance with the equipment requirements below, meet all of the RNP 5 requirements for up to 3.1 hours of flight time. This time starts when the systems are placed in the navigation mode or at the last point at which the systems are updated.

If systems are updated en route, the operator must show the effect that the accuracy of the update has on the time limit (see Section 8.6 below for information on the adjustment factors for systems that are updated en route).

> *NOTE: The 3.1 hours of flight time is based on an inertial system with a 95% Radial Position Error Rate (circular error rate) of 2.0 NM/hr which is statistically equivalent to individual 95% cross-track and 95% along-track position error rates (orthogonal error rates) of 1.6015 NM/hr each, and 95% cross-track and 95% along-track position error limits of 5 NM each (e.g. 5 NM/1.6015 NM/hr = 3.1 hours).*

Equipment requirements are;

(a) Dual FMSs which meets the specifications of FAA AC 25-15, Approval of Flight Management Systems in Transport Category Airplanes; FAA AC 20-129, Airworthiness Approval of Vertical Navigation (VNAV) Systems for use in the US National Airspace System (NAS) and Alaska;

(b) A flight director and autopilot control system capable of following the lateral and vertical FMS flight path.

(c) At least dual inertial reference units (IRUs).

(d) A database containing the waypoints and speed/altitude constraints for the route and/or procedure to be flown that is automatically loaded into the FMS flight plan.

(e) An electronic map.

8.3.2 Aircraft Equipped with INSs or IRUs Approved Under FARs Part 121, Appendix G

Inertial systems approved in accordance with FARs Part 121, Appendix G, are considered to meet RNP 5 requirements for up to 3.1 hours of flight time. This time starts when the system is placed in the navigation mode or at the last point at which the systems are updated. If systems are updated en route, the operator must show the effect that the accuracy of the update has on the time limit. INS accuracy, reliability and maintenance, as well as flight crew training, required by FARs Section 121.355 and Part 121 Appendix G, are applicable to an RNP 5 authorisation. Cross checking procedures associated with basic area navigation systems are applicable to operations with these navigation systems. Aircraft must be equipped with at least two eligible INSs.

8.3.3 Aircraft Equipped with Dual INSs or IRUs Approved to Minimum Navigation Performance Specification (MNPS) or Approved for RNAV Operations.

Aircraft equipped with dual INSs or IRUs approved for MNPS or RNAV operations (eg; Australia) normally meet RNP 10 requirements for up to 6.2 hours after the system is placed in the navigation (NAV) mode or following an en route update. The aircraft equipment would need further assessment for RNP 5 and the amended time limitation. If systems are updated en route, the operator must show the effect that the accuracy of the update has on the time limit. Section 12 provides a description of the updating procedures.

8.3.4 Aircraft Equipped with a Single INS/IRU and a Single Global Positioning System (GPS) Approved for Primary Means of Navigation in Oceanic and Remote Areas

Aircraft equipped with a single INS or IRU and a single GPS are considered to meet the RNP 5 requirements without time limitations. The INS or IRU must be approved to FARs Part 121, Appendix G. The GPS must be TSO-C129 authorised, and must have an approved dispatch Fault Detection and Exclusion (FDE) availability prediction program. The maximum allowable time for which the FDE capability is projected to be unavailable is 34 minutes. The maximum outage time must be included as a condition of the RNP 5 approval (see CAAP 1 for details on GPS as a primary means of navigation in oceanic and remote areas). The AFM must indicate that the particular INS/GPS installation meets the appropriate CAMA requirements.

8.3.5 Aircraft Equipped with Dual Global Positioning Systems (GPS) Approved for Primary Means of Navigation in Oceanic and Remote Areas

Aircraft approved to use GPS as a primary means of navigation for oceanic and remote operations in accordance with CAAP 1 are considered to meet the RNP 5 requirements without time limitations. The AFM(s) must indicate that a particular GPS installation meets the appropriate CAMA requirements. Dual TSO authorised GPS equipment is required, and an approved dispatch FDE availability prediction program must be used. The maximum allowable time for which FDE capability is projected to be unavailable is 34 minutes. The maximum outage time must be included as a condition of the RNP 5 approval. Refer CAAP 1, GPS for means of navigation in oceanic and remote areas).

NOTE: If predictions indicate that the maximum FDE outage time for the intended RNP 5 operation will be exceeded, then the operation must be rescheduled when FDE is available, or RNP 5 must be predicated on an alternate means of navigation.

8.3.6 Multi-Sensor Systems Integrating GPS (with GPS Integrity Provided by Receiver Autonomous Integrity Monitoring (RAIM))

Multi-sensor systems integrating GPS with RAIM or FDE, that are approved using the guidance of CAAP 1, GPS and meet airworthiness approval of navigation or flight management systems (FMS) integrating multiple navigation sensors, also meet RNP 5 requirements without time limitations. In this case, the INS or IRU must be approved in accordance with FARs Part 121, Appendix G.

8.4 Aircraft Eligibility Through Data Collection

A data collection program must address the appropriate navigational accuracy requirements for RNP 5. The data collection must ensure that the applicant demonstrates to the CAMA that the aircraft and navigation system provides the flight crew with navigation situational awareness relative to the intended RNP 5

route. The data collection must also ensure that a clear understanding of the status of the navigation system is provided, and that failure indications and procedures are consistent with maintaining the required navigation performance. Only one type of data collection method is described in this CAAP. The ***periodic method*** of data collection employs the use of a hand-held GPS receiver as a base line for collected INS data, which is described in Sections 10 and 11. The data collected is then analysed by the CAMA to determine if the system is capable of maintaining RNP 5 for the length of time needed by the operator.

8.5 Obtaining Approval for an Extended Time Limit for INS or IRU Systems.

The baseline RNP 5 time limit for INS and IRU systems after the system is placed in the navigation mode is 3.1 hours. This time limit may be extended by one of the following methods:

(a) An extended time limit may be established when RNP is integrated into the aircraft navigation system through a formal certification process (as described in Section 8.2).

(b) When an INS or IRU has been approved using an existing approval standard (as detailed in Sections 8.3.1, 8.3.2, and 8.3.3), an extended time limit may be established by an applicant presenting justifying data to the CAMA.

(c) An applicant may establish an extended time limit by showing that the carriage of multiple navigation sensors, that mix or average navigation position error, justifies such an extension (e.g. triple mixed INSs). If the applicant uses a time limit based on mixing, then the availability of the mixing capability must be operational at take-off for flight on RNP 5 routes or in RNP areas. If the mixing or averaging function is not available at take-off, then the applicant must use a time limit that does not depend on mixing. The extended time limit must be validated by a data collection program and analysis as specified in the following paragraph.

(d) When an INS or IRU has been approved using an existing approval standard, an applicant can establish an extended time limit by conducting a data collection program in accordance with the guidance provided in Section 12.

8.6 Effect of En route Updates.

8.6.1 General.

Operators may extend their RNP 5 navigation capability time by updating. Approvals for various updating procedures are based upon the baseline for which they have been approved minus the time factors shown below:

(a) Automatic updating using DME/DME = Baseline minus 0.3 hours (e.g. an aircraft that has been approved for 3.1 hours can gain 2.8 hours following an automatic DME/DME update).

(b) Automatic updating using DME/VOR = Baseline minus 0.5 hours.

(c) Manual updating using a method similar to that contained in Section 12 or approved by CAMA = Baseline minus one hour.

8.6.2 Conditions For Use of Automatic Radio Position Updating.

Automatic updating is any updating procedure that does not require flight crew to manually insert coordinates. Automatic updating is acceptable provided that:

(a) Procedures for automatic updating are included in an operator's training program.

(b) Flight crews are knowledgeable of the updating procedures and of the effect of the update on the navigation solution.

(c) An acceptable procedure for automatic updating may be used as the basis for an RNP 5 approval for an extended time as indicated by data presented to the CAMA. This data must present a clear indication of the accuracy of the update and the effect of the update on the navigation capabilities for the remainder of the flight.

8.6.3 Conditions For Use of Manual Radio Position Updating.

If manual updating is not specifically approved, manual position updates are not permitted in RNP 5 operations. Manual radio updating may be considered acceptable for operations in airspace where RNP 5 is applied provided that:

(a) Procedures for manual updating are reviewed by the CAMA on a case-by-case basis. An acceptable procedure for manual updating is described in Section 12 and may be used as the basis for an RNP 5 approval for an extended time when supported by acceptable data.

(b) The operator shows that updating procedures and training contain measures/cross checking to prevent human factor errors.

(c) The operator provides data that establishes the accuracy with which the aircraft navigation system can be updated using manual procedures and representative navigation aids. Data should be provided that shows the update accuracy achieved in normal service operations. This factor must be considered when establishing the RNP 5 time limit for INSs or IRUs

(d) Flight crew qualification syllabus is found to provide effective pilot training.

9. AIRCRAFT GROUPS (FLEETS OF AIRCRAFT)

9.1 Definition of an Aircraft Group

For aircraft to be considered as members of a group for the purposes of RNP 5 approval, they must satisfy the following conditions:

(a) Aircraft must have been manufactured to a nominally identical design and approved by the same Type Certificate (TC), TC amendment, or Supplemental Type Certificate (STC), as applicable.

NOTE: For derivative aircraft it may be possible to utilise the database from the parent configuration to minimise the amount of additional data required to show compliance. The extent of the additional data required will depend on the nature of the changes between the parent aircraft and the derivative aircraft when INS/IRU is used to meet RNP 5 navigational requirements.

(b) The navigation system installed on each aircraft to meet the RNP 5 approval must be manufactured to the manufacturer's same specifications and have the same part numbers.

NOTE: Aircraft which have INSs/IRUs which are of a different manufacturer or part number may be considered as part of the group, if it is demonstrated that this navigation equipment provides equivalent navigational performance.

(c) Where an approval is sought for an aircraft group, the data package must contain the following information:

(i). a list of the aircraft group to which the data package applies;

(ii). a list of the routes to be flown and the maximum estimated time from alignment to the time which the flight will leave Class II Navigation (see *Note* below for explanation of Class II Navigation);

(iii). the compliance procedures to be used to ensure that all aircraft submitted for approval meet RNP 5 navigational capabilities for the RNP 5 approved time duration; and

(iv). the engineering data to be used to ensure continued in-service RNP 5 capability for the RNP 5 approved time duration.

NOTE : Class II navigation is any en route operation which is conducted outside the operational service volumes of ICAO standard NAVAIDS (VOR, NDB, VOR/NDB). Class I operations are those conducted within the operational service volumes of ICAO standard NAVAIDS. These terms are used extensively in FAA documentation. Further explanation can be found in Order 8400.10 Air Transportation Operations Inspector's Handbook.

9.2 Definition of a Non-group Aircraft

A non-group aircraft is an aircraft for which an operator applies for approval on the characteristics of the unique airframe and navigation system used rather than on a group basis. For non-group aircraft where an airworthiness approval has been based on data collection, the continuing integrity and accuracy of the navigation system must be demonstrated by using the same amount of data collection as is required for group aircraft.

NOTE: Data collected by one or more operators may be used as the basis for approval by another operator and may reduce the number of trials required to obtain an RNP 5 approval. The following sections describe the data collection procedure and provide sample forms, which can be used to collect the data.

10. DATA COLLECTION PROCESS

10.1 Introduction

This section describes data collection procedures that have been approved by the CAMA on the basis of analysis of the data and multiple validation flights. Further, it is possible to evaluate triple-mix, individual units or both using this data collection procedure - the data collection forms are designed for this purpose.

There are two methods in which data may be collected.

10.1.1 GPS Reference.

One procedure is based upon the use of a hand-held Global Positioning System (GPS) as a base line for the correct position determination with the GPS readings and the data collection being taken by a non-essential flight crew member. Only authorised flight crews may operate the navigation system. Although no technical specifications are stated for the GPS unit used, it behooves operators to use the best quality unit that is practical. Poorer quality units might malfunction or provide erroneous data that will distort or negate the data collected and make the process excessively expensive.

10.1.2 Gate Position.

The second method uses a single, un-updated 'gate position' as a data point and performing the calculations at the end of this section to determine an RNP 5 limit. Operators wishing to use 'gate position' only, do not need to use the data pages but can go directly to the destination data page 5 and record the gate position data and time since last update.

11. DATA COLLECTION GENERAL INSTRUCTIONS

11.1 GPS Updating.

Pilots must not update the INS to a GPS position. This would invalidate the data.

11.2 Data Recording.

When recording data, all times are Universal Coordinated Time (UTC). Circle latitude and longitude senses (N or S, E or W). Record any additional information that could be helpful in analysing recorded data.

11.3 Page Heading.

Complete all sections of the heading **on each page**. This is important in the event that pages become separated and get mixed with data from other flights.

11.4 INS Initialisation.

Refer to data page 1 following this section.

(a) Record any unusual movement of the aircraft during INS initialisation before NAV mode selected, such as wind gusts, or an aircraft service vehicle bumping the aircraft, or settling during fuelling.

(b) If there was any unusual movement during INS alignment, record INS track (TK / GS) after NAV mode is selected.

(c) Record the published gate coordinates and/or GPS position where the INS is initialised.

(d) Was triple-mix selected? Check '*Yes*' or '*No*'.

(e) Check if updating is by radio navigation of position, '*Yes*' or '*No*'.

11.5 Times

Refer to data page 1 following this section.

(a) Before departure, record the time the pilots are observed putting the INS NAV mode selectors in NAV.

(b) Record OFF time.

(c) Record the time leaving Class II navigation when radar contact is first established.

(d) Record IN (at the gate) time.

11.6 Destination Gate Positions

Refer to data page 5 following this section.

11.7 1/2 Hourly Position Readings

Refer to data pages 2 to 4 following this section.

(a) Once each 30 minutes after takeoff (ACARS OFF time), plus or minus 5 minutes, record GPS and INS positions. Do not record data during climb or

descent, during pilot INS Waypoint Change procedures or at other times when pilots obviously are busy with other tasks, such as ATC or cabin communications.

(b) Record the desired track (DSRTK/STS) of steering INS.

(c) Record the last and next waypoints lat/long and name.

(d) Freeze the GPS and INS positions simultaneously.

(e) Record GPS position.

(f) Record INS updated / triple-mix positions (HOLD and POS selected).

(g) Record the INS un-updated (Inertial) positions. (HOLD and WAY PT, thumbwheel other than 0 selected).

(h) Release the frozen INS and GPS positions.

11.8 En route INS Updates.

Record the following separately only if manual updating is being evaluated.

NOTE: There is no data sheet example for radio navigation updates.

(a) Record the identifier of the navaid over which updating is accomplished and the navaid coordinates.

(b) Record the number of GPS satellites in view and the GPS PDOP value.

(c) Record the time when INS coordinates are frozen before the en route update is accomplished.

(d) After INS positions are frozen and before an updated position is entered:

(i) Record the INS updated / triple-mix positions and INS un-updated positions;

(ii) Record the GPS position.

11.9 Radio Navigation INS Updates

Record the following separately only if manual updating is being evaluated (e.g. ground based radio navigation positions are used for INS updates).

NOTE: There is no data sheet example for radio navigation updates.

Record:

(a) Navaid identifiers.
(b) Aircraft position derived from ground navaids (update position).
(c) Time of update.
(d) INS position before update.
(e) GPS position

Flight No……..UTC Departure Date……Departure Aerodrome……..

Aircraft Type……A6-……Arrival Aerodrome……Captain……

INS INITIALISATION

(1) Were there any unusual motion events during alignment? *Yes* *No*

If *Yes*, INS Track (TK/GS).....
If *Yes*, provide a brief description of the event(s):
.....
.....
.....

(2) INS initialisation coordinates (published or GPS): N / S .....

E / W.....

(3) Triple-mix selected? *Yes* *No*

(4) Radio navigation updating? *Yes* *No*

TIMES

OFF	.....Z
Time NAV mode selected	.....Z
Time in NAV mode before take-off	.....Hrs .....Mins
Time entering Class II nav airspace	.....Z
Approx time leaving Class II nav airspace	.....Z
Time NAV mod selected	.....Z
Approx time in NAV mode before leaving Class II airspace	.....Hrs.....Mins
IN	.....Z
Time NAV mode selected	.....Z
Total time in NAV mode	.....Hrs.....Mins

Data Page 1

DATA POINT 1	Z		Altitude	
GPS	No. Of SV	DOP	EPE	
GPS Position	N/S		E/W	
Updated / Triple-Mix Positions			Un-Updated Positions	
		INS 1		
		INS 2		
		INS 3		
LAST WAYPOINT		NAME		N/SE/W
NEXT WAYPOINT		NAME		N/SE/W

DATA POINT 2	Z		Altitude	
GPS	No. Of SV	DOP	EPE	
GPS Position	N/S		E/W	
Updated / Triple-Mix Positions			Un-Updated Positions	
		INS 1		
		INS 2		
		INS 3		
LAST WAYPOINT		NAME		N/SE/W
NEXT WAYPOINT		NAME		N/SE/W

Data Page 2

DATA POINT 3	Z		Altitude	
GPS	No. Of SV	DOP	EPE	
GPS Position	N/S		E/W	
Updated / Triple-Mix Positions			Un-Updated Positions	
		INS 1		
		INS 2		
		INS 3		
LAST WAYPOINT		NAME		N/SE/W
NEXT WAYPOINT		NAME		N/SE/W

DATA POINT 4	Z		Altitude	
GPS	No. Of SV	DOP	EPE	
GPS Position	N/S		E/W	
Updated / Triple-Mix Positions			Un-Updated Positions	
		INS 1		
		INS 2		
		INS 3		
LAST WAYPOINT		NAME		N/SE/W
NEXT WAYPOINT		NAME		N/SE/W

Data Page 3

DATA POINT 5	Z		Altitude	
GPS	No. Of SV	DOP	EPE	
GPS Position	N/S		E/W	
Updated / Triple-Mix Positions			Un-Updated Positions	
		INS 1		
		INS 2		
		INS 3		
LAST WAYPOINT		NAME		N/SE/W
NEXT WAYPOINT		NAME		N/SE/W

DATA POINT 6	Z		Altitude	
GPS	No. Of SV	DOP	EPE	
GPS Position	N/S		E/W	
Updated / Triple-Mix Positions			Un-Updated Positions	
		INS 1		
		INS 2		
		INS 3		
LAST WAYPOINT		NAME		N/SE/W
NEXT WAYPOINT		NAME		N/SE/W

Data Page 4

DESTINATION GPS / INS POSITIONS

- Please do not remove INS updates until up-dated / triple-mix positions are recorded at the gate.

(1) Destination Gate No. .....

(2) Published Position N / S .....

E / W .....

GPS	No. of SV	DOP	EPE
GPS Position	N/S	E/W	

Triple-Mix Positions	Un-Updated Positions	Distance

- Name of person recording data (Please print): .....
- Position: .....
- Name of Company: .....
- Address: .....

.....
.....
.....

- Telephone Number: .....(Business).....(Home)
- Facsimile Number: .....
- E-mail Address: .....

Destination Data Page 5

12. MANUAL UPDATING PROCEDURE FOR RNP 5.

12.1 Introduction

In order to facilitate RNP 5 operations for airborne navigation systems that are unable to achieve RNP 5 performance for greater than 3.1 hours, the following methods of manual position updating are suggested as a means to extend the 3.1 hours. Manual position updating is defined to mean a technique where the crew uses one of the techniques described below to adjust their INS output to compensate for the detected error. The detected error is the difference between the radio navigation position and the INS/IRU position with the radio navigation position being considered the correct position.

Two techniques using VOR/DME or TACAN and one technique using a Global Positioning System are possible means of manual updating. The first is a position update based on crossing a fix along a route defined by a bearing and distance from/to a VOR/DME or TACAN facility. The second is based on a route that over flies a VOR/DME or TACAN facility. The third is similar to the first but uses a TSO C-129 authorised GPS receiver with an approved installation for the update in place of a navigation aid. In each of the three methods, a log (the plotting chart used in each of the procedures is an acceptable log if all required data is entered on the chart) of the procedure must be made of the data and maintained by the operator for a period of 30 days.

The conditions under which either method may be used are as follows:

(a) Class II Inertial Navigation Systems meeting FARs Part 121, Appendix G requirements or the criteria established in Advisory Circular 25-4, Inertial Navigation Systems (INS) are used.

(b) For the first and second methods the minimum distance from the reference VOR/DME facility must be at least 50 NM.

(c) Both the VOR and DME functions of the reference facility must be operational prior to dispatch release and during the intended updating operation unless the GPS procedures is used as a reference.

(d) The flight crew must have in its possession a plotting chart with the information specified in this Section.

12.2 Mandatory Data For All Updating Methods (plotting chart required).

INS INITIALIZATION

(1) Were there any unusual motion events during alignment? *Yes* *No*

If *Yes*, INS Track (TK / GS): .....
If *Yes*, provide a brief description of the event(s): .....

.....

.....

.....

(2) INS initialisation coordinates (published or GPS): N / S.....

E / W.....

(3) Triple-mix selected? *Yes* *No*

(4) Radio navigation updating? *Yes* *No*

TIMES

- PRIOR TO TAKE-OFF

OFF .....Z
Time NAV mode selected .....Z

Time in NAV mode before take-off .....Hrs .....Mins

- FLIGHT PHASE

Time entering Class II nav airspace .....Z

Approx time leaving Class II nav airspace .....Z
Time NAV mod selected .....Z
Approx time in NAV mode
before leaving Class II airspace .....Hrs.....Mins

- ARRIVAL PHASE

IN .....Z
Time NAV mode selected .....Z

Total time in NAV mode .....Hrs.....Mins

12.3 Method 1: Manual Updating Based on Crossing a Fix En route.

(a) Using Method 1, the update is performed when crossing over a fix that is defined by a crossing radial and distance from a VOR/DME or TACAN facility. To accomplish this update, the crossing radial must be at or near perpendicular to the route. The minimum DME /TACAN distance used to define the fix location shall be at least 50 NM.

(b) The flight crew should tune in the reference VOR/DME or TACAN facility and pre-select the appropriate bearing on one CDI. As the CDI centers, the flight crew will note the distance from the VOR/DME facility and mark it on the plotting chart. The flight crew will also note the inertial positions of each of the operating INS. The crew will then compare the inertial position against the derived position. The crew then may use the derived position (expressed in lat/long) to update the inertial position. If interpolation is necessary, round up. This procedure would provide a means to re-start the RNP 5 clock for an additional predetermined time.

(c) To accomplish this manual update, the flight crew should have a plotting chart that displays the route fix and DME fixes of one mile increments located along a line that is perpendicular or near perpendicular to the route along the axis of the VOR radial used to define the fix. Each fix should be displayed in both DME distance and latitude/longitude coordinates.

(d) Put two fixes along the route, one on either side of the 'update' fix and note the coordinates on the plotting chart. Crews should then use these fixes to validate the position update. This is similar to the method used for updating when flying on a route that passes over a VOR/DME facility. It is imperative for crews to remember that these additional fixes are to be used for verification only, not as an update fix. They do, however, provide a means of verification of the update.

12.4 Method 2: Manual Updating En route by a VOR/DME Facility.

(a) The accuracy of a manual update when over flying a VOR/DME facility is questionable due to the 'cone of confusion' that exists overhead the facility and varies as a function of the altitude of the aircraft. To increase the accuracy of a manual update in this situation, it is recommended that a plotting chart be created that has fixes depicted along the route at a minimum distance of 50 NM, but not more than 60 NM from the VOR/DME. These fixes should display the bearing and distance and the latitude/longitude coordinates expressed to a tenth of a degree. The specified distances will account for slant range error and radial width.

(b) In this situation, the suggested procedure would be for the flight crew to discontinue INS navigation when receiving the VOR/DME signal and attempt to align the aircraft exactly on the desired radial to or from the station. When passing over the specified fix, the crew will compare each of the INS positions with the reference lat/long position of the fix. The manual update should be attempted if the along track position error is greater than 1 NM. After the manual update is completed, the crew should continue to navigate by the VOR radial to the next designated fix and compare the coordinates to verify that the update was successful.

(c) As minimum requirements for use of these procedures, the crew must have on board the appropriate plotting charts with the specified information, and the operator must demonstrate that its crews know how to use the charts and procedures.

(d) These procedures should be based on the assumption that triple mix position fixing is not used, and each inertial must be updated accordingly. The crew must notify ATC anytime it becomes aware that the aircraft can no longer maintain RNP 5 performance based on evaluation of the position checks.

12.5 12.5 Method 3: Using GPS as an Updating Reference.

(a) Using Method 3, the update is performed by comparing the INS position to the GPS position at a chosen way point.

(b) Prior to departure the mandatory data must be logged.

(c) Updating:
- (i) Record the time when INS coordinates are frozen before the en route update is accomplished and the flight level.
- (ii) Record the number of GPS SVs (Satellite Vehicles) locked on and the GPS DOP and Estimated Position Error (EPE) values.
- (iii) Record the desired track (DSRTK / STS) of the steering INS.
- (iv) Freeze the GPS and INS positions simultaneously.
- (v) From the data determine the approximate amount of drift per hour flown, make appropriate corrections and continue to navigate.
- (vi) If data indicates that RNP 5 capability is impossible to maintain, ATS must be notified as soon as flight conditions will permit.

(d) Completion of Class II Navigation and Post Flight: This step is important in that it verifies the accuracy of the updating process and will warn operators if there is an equipment or procedural problem that might effect future flights.

(i) Record the time leaving Class II navigation when radar contact is first established or when first within 150 NM of a VOR navaid, Record IN time.
(ii) Destination Gate Positions: Do not remove INS updates until updated INS is recorded at the gate.
(iii) Record the destination gate number, the number of GPS SVs (Satellite Vehicles) in view and the GPS DOP and EPE values.
(iv) Record updated INS positions.
(v) Remove INS updates.
(vi) Record INS un-updated positions and INS distances from the gate position.
(vii) Record GPS position. If GPS position is unavailable, record the gate position.
(viii) INS data should be recorded in the Maintenance Log as usual.
(ix) Release the frozen INS positions.

13. RNP 5 DATA REDUCTION TECHNIQUES FOR DATA COLLECTED (CAMA USE ONLY)

13.1 Procedure.

Flight Operations Inspectors should complete the following steps;

(a) Collect reference data (GPS) and INS/IRU data, which should have been taken every 30 minutes after reaching initial cruise altitude (Lat, Long, Height and time at the same time for each system).

(b) Determine North-South and East-West error in NM (Difference between GPS and INS/IRU position translated into NM).

(c) Graph position error (using GPS as reference) versus time for each flight.

(d) Since the actual time of measurement and the test time interval will vary, establish on each flight chart (plot) an equally spaced interval.

(e) At each time interval calculate the radial position error for each flight (This requires interpolation of the North-South, East-West data from the graphs).

(f) This radial error is the data used to determine the 95 percentile level of error. 'The 95 percentile error level of error' is used here to mean that it is 95 % probable that the error in a given flight will fall below this level or that the level will be below this level in 95% of flights if the number of flights is very large.

(g) After collecting the data for all flights, calculate the Root-Mean-Square (RMS) and Geometric Mean (GM) of the radial errors for each elapsed

time point. Also determine the ratio of GM/RMS for each elapsed time point.

$$RMS = \left(\frac{1}{n} \sum_{i=1}^{i=n} r_i^{\,2} \right)^{1/2}$$

$$GM = \left(\prod_{i=1}^{i=n} r_i \right)^{1/n}$$

where:

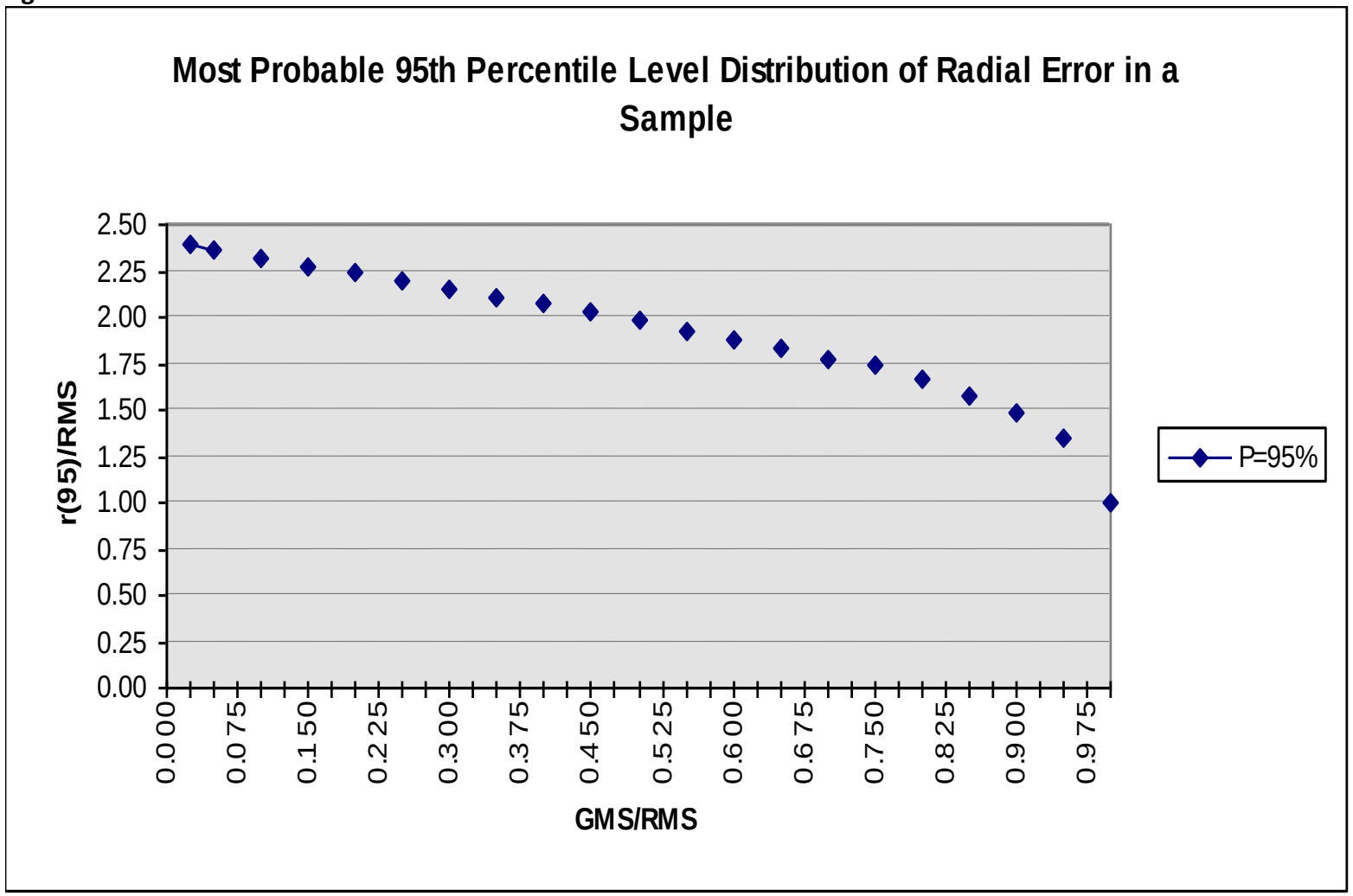
r = radial error at elapsed time point
n = number of observations of radial error at equally spaced time intervals

(h) Using the P=95 curve from Figure 1 below, find the value of $r_{(P)}$/RMS for the calculated value of GM/RMS. Multiply this $r_{(P)}$/RMS factor by the value of RMS to determine an estimate of the 95th percentile value of radial error at this elapsed time point.

(i) Repeat the above procedure for each elapsed time point. Graph $r_{(95)}$ values of radial error (in NM) versus elapsed time since entering the NAVIGATE mode.

(j) Pass-Fail Criteria. The elapsed time when radial error $r_{(95)}$ exceeds 5 NM defines maximum flight time wherein the navigation system meets RNP 5 criteria.

Figure 1


Most Probable 95th Percentile Level Distribution of Radial Error in a Sample
r(95)/RMS
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
0.000
0.075
0.150
0.225
0.300
0.375
0.450
0.525
0.600
0.675
0.750
0.825
0.900
0.975
GMS/RMS
P=95%

13.2 Periodic Method Example

As an example, a 6 flight data set is used (in actual practice a much larger data set should be used to provide confidence). For simplicity of illustration, this example uses only the Triple-Mix positions after 10 hours in NAV (the time was an arbitrary selection to illustrate the means of calculation). Data for individual navigation units is not included in this example; if they had been used they would be calculated in exactly the same manner that the Triple-Mix data is calculated in the example. If an operator decided to use gate position only Figure 3 should be used.

The symbols used in the figures below are:

r = radial error

r^2 = square of the radial error

IIr = product of radial errors

$\sum$ = Sum

$\sum r^2$ = Sum of the squares of the radial errors

Figure 2: Table of Radial Errors 'r' (Use for Airborne Data Collection)

Flight	Radial errors = r	r^2
1	6.5	42.25
2	5.5	30.25
3	12.7	161.22
4	14.0	196.00
5	7.2	51.84
6	7.0	49.00

The product (**II**) of radial errors (column 2) = 320,360

The sum of the radial errors squared ($\sum r^2$) (column 3) = 530.63

Calculations:

$$RMS = \left(\frac{1}{n} \sum_{i=1}^{i=n} r_i^{\,2} \right)^{1/2} = (1/6\ (530.63))^{1/2} = 9.40$$

$$GM = \left(\prod_{i=1}^{i=n} r_i \right)^{1/n} = (320.36)^{1/6} = 8.27$$

RATIO = GM/RMS = 8.27/9.40 = 0.88

Find this value (0.88) on the abscissa of the 'Most Probable Graph' and intersect it with the 95% curve to find $r_{(95)}$ /RMS (on the ordinate of the graph).

Thus $r_{(95)}$ /RMS = 1.47 (for this example). The ordinate is defined as $r_{(95)}$ /RMS where

$r_{(95)}$ = 95 percentile of error. Now $r_{(95)}$ for the data in the example is determined from the following:

$r_{(95)}$ = Ordinate value (for the data) x RMS = 1.47 x 9.40 = 13.8 NM

These results indicate that the 95 percentile level of error at 10 hours is 13.8 NM which is greater than the required 5 NM and the system would not qualify for RNP 5 for 10 hours based on the data presented. Guidance on gate position data collection is shown below.

Figure 3: Table of Radial Errors (Use for Gate Position Data)

Note: No data is provided for this method. Calculations would be made identical to the procedure used in Figure 2.

Time is critical with this set of data and it should be noted that the credited time is that of the smallest time value in the data set.

Flight	Times since last update	Radial Error at Gate = r	r^2

(1) The product (**II**) of radial errors (column 3) = _____

(2) The n^{th} root of **II** = _____ = GM

(3) The sum of the radial errors squared ($\sum r^2$) (column 4) = _____

(4) The square root of ($\frac{1}{n}$ ä $r_i^{\,2}$) = _____ = RMS

After calculating (2) and (4) use Figure 2 to determine $r_{(95)}$. Multiply this factor by the RMS to determine the drift in NM. If this value is less than 5 NM then the navigation system can be approved for RNP 5 for the time in nav of this flight. Note that this is the data for one flight only, data must be collected in the same manner and in an equal time length for a minimum of 20 flights.

14. FLYING OPERATIONS INSPECTOR'S CHECK LIST

APPLICANT	SECTION	FOI INIT.	DATE
1. FOI familiarisation with the approval process	Section 7.		
2. Set up applicant meeting date	Section 7.1		
3. Application meeting: FOI ..... Applicant's understanding of CAAP 2 & 3 Check of documentation - RNP time requested for specific route or area - Airworthiness documentation - Current Operations Specifications, if applicable - Current *Approval*, if applicable - Copy of pertinent sections of the AFM - List of number and type of Long Range Navigation (LRNS) units (e.g. 3 x Litton 92, INS) - Description of LRNS integration - Description of updating procedures, if used - Review of training programme - RNP 5 operations issues - RNP 5 contingency procedures - Updating procedures and implications of the update on the navigation solution (if updating is planned).			

4. Evaluate Operator's Long Range Navigation System – Determine Eligibility Group Choose one of the following as a means by which approval will be accomplished: - The operator has an AFM entry or other documentation from CAMA Airworthiness Branch/Officer granting certification approval for RNP 5 or better for a specific time period. - Plan on approving the operator for unlimited RNP 5 naviga either one or both of the required LRNSs is a GPS and the are integral to the primary steering instrument of the man flight crew. GPS approval guidance is contained in CAAP 1 - Approve the operator for the RNP value and time specified in the AFM. - Approve the operator for RNP 5 for 3.1 hours.	Section 8 Section 8.2 Section 8.2		

FLYING OPERATIONS INSPECTOR'S CHECK LIST(Continued)	SECTION	FOIINIT.	DATE
4. Evaluate Operator's LRNSs (continued)			
▯ Determine if approval of additional time will be needed. If 'Yes', then a discussion of one of the extended time procedures will be required.	Section 8.3		
- Request that operational navigation performance data be presented	Section 8.4		
- Determine if the operator has updating procedures. If 'Yes', then the procedures for its use must be contained in the training curriculum and crews must be knowledgeable in its use and its effect on the navigation solution. If 'No', then advise operator that a data collection program based on one of the following will be required prior to granting approval	Section 12		
Periodic data collection based upon a portable GPS being used for a base-line (see Section 11) or data collection based upon the radial error determined from destination gate positions.	Data pages		
5. Data Analysis Meeting			
- Check all data required and discussed at the application meeting.	Section 11 and data pages		
- Be especially aware that the documentation is consistent with the equipment actually installed in the aircraft.			
- Check training curriculum or in the case of general aviation operators, the knowledge of the person endorsing the crew knowledge section of the 'Instrument of Approval'.	CAAP 2		
- If data collection was required, examine it closely. If any doubt exist as to the validity or integrity of the data, contact one of CAMA's navigation specialists.	Section 13		
6. Issue *Approval* in Operations specifications to the operator after compliance with CAAP 2	CAAP 2		