



Advisory Circular

AC 91U-2(0)

NOVEMBER 2005

REQUIRED NAVIGATION PERFORMANCE 10 (RNP 10) OPERATIONAL AUTHORISATION

CONTENTS

1. References	2	Appendix 1 - Aircraft Eligibility through Data Collection	18
2. Purpose	2	Appendix 2 - Certification of IRU Performance	28
3. Status of this AC	2	Appendix 3-A - Sample Letter of Request for 'RNP10 Operational Authorisation'	30
4. Background	2	Appendix 3-B - Sample 'RNP 10 Operational Authorisation'	31
5. Applicability	2	Appendix 4 - Training Programs, Operating Practices and Procedures	32
6. Related Publications	3	Appendix 5 - Checklist for the RNP) 10 Authorisation Application Process	34
7. Operational Authorisation	3	Appendix 6 - A Sample Data Collection Process (Periodic Method)	37
8. Operational Authorisation Process	4	Appendix 7 - An Approved Manual Updating Procedure for RNP 10 Operations	50
9. Application	5	Appendix 8 - Transport Category Aircraft Equipage	55
10. RNP 10 Requirements and Definitions	7		
11. Aircraft Groups (Fleets of Aircraft)	8		
12. Determination of Aircraft Equipment Eligibility	9		
13. Minimum Equipment List (Mel)	14		
14. Continuing Airworthiness (Maintenance Requirements)	14		
15. Operational Requirements	14		
16. Discussion of Certification Actions related to RNP 10	16		

Advisory Circulars are intended to provide advice and guidance to illustrate a means but not necessarily the only means of complying with the Regulations, or to explain certain regulatory requirements by providing informative, interpretative and explanatory material.

Where an AC is referred to in a 'Note' below the regulation, the AC remains as guidance material.

ACs should always be read in conjunction with the referenced regulations

1. REFERENCES

CASR 91.850 and Subpart 91.U

Manual of Standards (MOS) Subpart 91.U, Chapter 3

ICAO Doc 7030/4, MID/ASIA/RAC and PAC/RAC

Aeronautical Information Publication (AIP)

2. PURPOSE

This Advisory Circular (AC) provides Australian aircraft owners and operators with comprehensive information on a means of gaining an authorisation to undertake 'RNP 10 operations' i.e. obtain an *RNP 10 Operational Authorisation*.

3. STATUS OF THIS AC

This AC replaces Civil Aviation Advisory Publication (CAAP) RNP 10-1. The information has been revised and updated but the changes are mostly editorial. The technical requirements for RNP 10 authorisation have **not** been altered.

4. BACKGROUND

Through ICAO and regional planning groups, 50 NM lateral and 50 NM longitudinal separation minima have been implemented in oceanic and remote airspace in a number of areas, for example the South Pacific (SOPAC) - including the Tasman Sea, the Northern Pacific (NOPAC), Central East Pacific (CEP), and the Central Pacific (CENPAC). Navigation accuracy, expressed as Required Navigation Performance 10 (RNP10), forms an integral part of the application of 50/50NM separation minima.

In accordance with ICAO Annex 6, operators must obtain a RNP 10 operational authorisation from the operator's State of Registry or State of the Operator in order to be separated by a minimum of 50NM from other RNP 10 approved aircraft in oceanic or remote airspace or conduct flights in airspace where RNP 10 has been mandated for other reasons. Such operations can be classified as RNP 10 operations

The AC lists the mandatory airworthiness and operational (including flight crew training) standards that must be met before an *RNP 10 Operational Authorisation* will be granted by CASA. These standards are set out in the Manual of Standards (MOS) Subpart 91.U, Chapter 3, and have mandatory effect by virtue of being required by the regulations. The source document for the MOS are the technical, operational and training standards contained in the guidance material for the RNP 10 operational approval process - Appendix E of the Manual on Required Navigation Performance (RNP), ICAO Doc 9613-AN/937. The standards/mandatory requirements are expressed as a 'must' in the text of this AC since they are mandatory standards under the regulations.

5. APPLICABILITY

This AC is for use by Australian operators, those who own/operate either Australian or foreign registered aircraft, and their flight crews.

An *RNP 10 Operational Authorisation* (or equivalent approval/qualification from another State) is not mandatory in order to gain access to Australian 'RNP airspace'.

However, authorisation must be obtained from CASA for RNP 10 operations to be conducted by the operator/flight crew.

Australian registered aircraft, when operating outside Australian territorial airspace (i.e. beyond the 12 NM territorial limit) must comply with ICAO Annex 2 when over the high seas (Civil Aviation Regulation 3 (3)) and other States' regulations when operating within their airspace (CAR 223). Note that the Civil Aviation Regulations (CAR) will be replaced in the future by the equivalent CASR Part 91 regulations.

6. RELATED PUBLICATIONS

For further information on this topic, operators are advised to review the following publications/regulatory requirements.

(a) Airservices Australia (AsA)

Air Services Regulation 2.04

(b) Federal Aviation Administration (FAA)

AC 20-130A

AC 20-138A

Order 8400.12A

(Provides a list of all FAA documents used to develop the Order)

Federal Aviation Regulations Part 121 Annex G

(c) International Civil Aviation Organization (ICAO)

Manual on Required Navigation Performance (RNP), ICAO DOC 9613- AN/937

Annex 6, Chapter 7

(Copies may be obtained from Document Sales Unit, ICAO, 999 University Street, Montreal, Quebec, Canada H3C 5H7)

(d) RTCA, Inc

Minimum Aviation System Performance Standards (MASPS): Required Navigation Performance for Area Navigation, RTCA.

(Copies may be obtained from RTCA, Inc., 1828 L Street NW, Suite 805, Washington, DC 20036).

7. OPERATIONAL AUTHORISATION

7.1 Overview

CASA and the operator must carry out the following steps so that CASA has sufficient information to issue an *RNP 10 Operational Authorisation*:

- (a) aircraft equipment eligibility for RNP 10 will be determined by CASA;
- (b) flight crew training and operating procedures for the navigation systems to be used must be identified by the operator; and
- (c) the operator database use, flight crew training and operating procedures will be evaluated by CASA.

7.2 Database of approved aircraft and systems

CASA's Air Transport Operations Group (ATOG) in Central Office will maintain a database of aircraft/navigation systems and operators that have received an *RNP 10 Operational Authorisation*.

The database will be maintained for airspace safety monitoring purposes and will also provide information to other CASA offices and operators on those aircraft and navigation systems that have been approved. The database may be provided to other States and airspace monitoring agencies to enable them to undertake airspace system safety checks.

8. OPERATIONAL AUTHORISATION PROCESS

8.1 Introduction

In addition to providing advice on the authorisation process including the mandatory standards applicable in MOS Subpart 91.U, Chapter 3, this AC provides guidance on aircraft certification where RNP 10 eligibility cannot otherwise be determined, or where the operator chooses to lengthen the RNP 10 time limits.

Appendix 5 shows a combined checklist as well as the CASA Flying Operations Inspector's 'Check List' that can be used to facilitate the application process.

8.2 Pre-application meeting

Each individual operator should schedule a pre-application meeting with the CASA Airline/Area office responsible for its operations.

The intent of this meeting is to discuss with the operator CASA's airworthiness and operational requirements for issuing an authorisation, including:

- (a) what should be included in the operator's application;
- (b) how CASA will review and evaluate the application;
- (c) what limitations (if any) will be placed on the authorisation; and
- (d) what are the conditions under which the operational authorisation may be cancelled by CASA.

8.3 Form of application

A sample of a *Letter of Request* that can be used by an operator to apply for an *RNP 10 Operational Authorisation* is shown in Appendix 3-A.

8.4 Determination of eligibility and authorisation for RNP 10

Many aircraft and navigation systems currently in use in oceanic or remote area operations will qualify for RNP 10 based on one or more provisions of existing certification criteria.

Additional aircraft certification action may only be necessary if the operator chooses to claim additional performance beyond that originally certified or stated in the Aircraft Flight Manual (AFM) and the operator cannot demonstrate the desired performance by means of data collection.

9. APPLICATION

9.1 Contents of an operator's RNP 10 application

9.1.1 Eligibility airworthiness documents

The applicant must ensure that relevant documentation (e.g. the AFM) is available to establish that the aircraft is equipped with Long Range Navigation Systems (LRNSs) that meet RNP 10 requirements.

9.1.2 Description of aircraft equipment

The applicant must provide a configuration list which details components and equipment to be used for long-range navigation and RNP 10 operations.

9.1.3 RNP 10 time limit for inertial navigation systems (INS) or inertial reference units (IRU) (if applicable)

The applicant must provide their RNP 10 time limit for the specified INS or IRU (see Section 12). The applicant must consider the effect of headwinds in the areas where RNP 10 operations will be conducted (see Section 15) to determine the feasibility of the proposed operation.

Operators of aircraft that are unable to couple the RNAV systems to the flight director or to the autopilot must assume a Flight Technical Error (FTE) of 2 NM for oceanic operations. The addition of the 2 NM FTE to the assumed navigation position error will further time limit INS/IRU equipped aircraft undertaking RNP 10 operations.

9.1.4 Operational training programs and operating practices and procedures

Air Operator Certificate (AOC) holders must submit training syllabi and an example of one training program to the appropriate CASA Airline/Area office to show that the operational practices and procedures and training items related to RNP 10 operations have been incorporated in the relevant training programs (e.g. initial, upgrade, recurrent). Practices and procedures in the following areas must be standardised using the material shown in Appendix 4: flight planning; pre-flight procedures at the aircraft for each flight; procedures before entry into an RNP 10 route or airspace; in-flight, contingency and flight crew qualification procedures.

Private operators must produce evidence that they will operate using the practices and procedures identified in Appendix 4.

9.1.5 Operations manuals and checklists

AOC holders must revise their operations manual and checklists to include information on standard operating procedures, as detailed in Appendix 4. Appropriate manuals should include navigation operating instructions and contingency procedures where specified i.e. weather deviation procedures. Manuals and checklists must be submitted for review by CASA as part of the application process.

Private operators must revise the appropriate manuals to include navigation operating instructions and contingency procedures. The manual(s) and the aircraft navigation equipment manufacturer's checklist, as appropriate, must be submitted for review as part of the application process.

9.1.6 Past performance

An operating history must be included in the application. The applicant must address any incidents related to navigation or equipment errors experienced (e.g. as reported in a *CASA Navigation Error Investigation Form*) that have been covered by training, procedures, maintenance, or aircraft/navigation system modifications.

9.1.7 Minimum equipment list (MEL)

Any MEL revisions necessary to address the RNP 10 provisions of the guidance material in this AC must be approved (e.g. if authorisation is based on 'Triple-Mix' the MEL must reflect that three navigation units must be operating).

9.1.8 Maintenance

Where applicable, the operator must submit a maintenance program for approval, in accordance with Sections 13 and 14, at the time of application.

9.2 Evaluation, investigation and cancellation

9.2.1 Evaluation of applications

Once the application has been submitted, CASA will begin the process of review and evaluation in order to determine if the regulatory requirements have been met. If the content of the application is not comprehensive, CASA will request additional information from the operator.

When all the airworthiness and operational requirements of the application are met, the applicable Airline/Area Office Flying Operations Team Leader will issue the authorisation to enable the operator to undertake RNP 10 operations.

In accordance with the regulations, the *RNP 10 Operational Authorisation* will identify any conditions or limitations on operations in RNP 10 airspace, e.g. required navigation systems or procedures; limits on time, routes or areas of operation. A sample of the authorisation is shown in Appendix 3-B.

9.2.2 Investigation of navigation and system errors

Demonstrated navigation accuracy provides the basis for determining the lateral route spacing and separation minima. Lateral and longitudinal navigation errors are investigated by CASA to prevent their recurrence.

Air Traffic Control (ATC) facilities will make radar observations of each aircraft's proximity to track and altitude, before coming into coverage of short-range nav aids at the end of the oceanic route segment.

CASR 91.5170 requires that navigation errors must be reported to CASA when the following parameters apply:

- (a) lateral navigational errors of 15 NM or more;
- (b) longitudinal navigational errors of 10 NM or more;
- (c) longitudinal navigational errors or 3 minutes or more variation between the aircraft's estimated time of arrival at a reporting point and its actual time of arrival;
or
- (d) navigation system failures.

If an aircraft is not within the established limits, the reason(s) for the apparent deviation from track or altitude or system failure will be reviewed by CASA.

9.2.3 Cancellation of RNP 10 operational authorisation

CASA may consider any navigation error reports in determining remedial and enforcement action. Repeated navigation error occurrences attributed to a specific piece of navigation equipment may result in cancellation of the *RNP 10 Operational Authorisation* for use of that equipment/aircraft.

The operator may need to modify their training programs if there are repeated errors or conduct remedial training of pilots or a license review.

10. RNP 10 REQUIREMENTS AND DEFINITIONS

10.1 Cross-track and along-track requirements

As stated in the MOS Subpart 91.U, Chapter 3, all aircraft undertaking RNP 10 operations must have a cross-track Total System Error (TSE) no greater than +/-10 NM for 95% of the flight time. This includes Position Estimation Error (PEE), Flight Technical Error (FTE), Path Definition Error (PDE) and display error.

All aircraft must also have an along-track TSE error no greater than +/-10 NM for 95% of the flight time.

Note: For RNP 10 authorisation of aircraft capable of coupling the RNAV system to the flight director or autopilot, navigational positioning error is considered to be the dominant contributor to cross-track and along-track error. Flight technical error, path definition error, and display errors are considered to be insignificant for the purposes of authorisation.

10.2 Types of errors

When using the method described in Appendix 1 as the basis for RNP 10 authorisation, the error types noted in Section 10.1 are included, but for the data collection method described in Appendix 6, they are not since the Appendix 6 method is more conservative. The Appendix 6 method uses radial error instead of cross-track and along-track error.

10.2.1 Flight technical error (FTE)

FTE is the accuracy with which the aircraft is controlled, as measured by the indicated aircraft position with respect to the indicated command or desired position. It does not include blunder or gross navigation errors (GNEs).

Note: For aircraft that are not capable of autopilot or flight director coupling, an FTE of 2 NM for oceanic operations must be taken into account by CASA in determining any limitations.

10.2.2 Path definition error (PDE)

PDE is the difference between the *defined path* and the *desired path* at a specific point and time.

10.2.3 Display system errors

These errors may include error components contributed by any input, output or signal conversion equipment used by the display as it presents either aircraft position or guidance commands (e.g. course deviation or command heading) and by any course definition entry device employed. For systems in which charts are incorporated as integral parts of the display, the display system error necessarily includes charting errors to the extent that they actually result in errors in controlling the position of the aircraft relative to a desired path over the ground.

To be consistent, in the case of symbolic displays not employing integral charts, any errors in waypoint definition, directly attributable to errors in the reference chart used in determining waypoint positions, should be included as a component of this error. This type of error is virtually impossible to handle and in general practice, highly accurate, published waypoint locations are used to the greatest extent possible in setting up such systems to avoid such errors and reduce workload.

10.2.4 Navigation system error (NSE)

NSE is the ‘root-sum-square’ of the ground station error contribution, the airborne receiver error and the display system contribution.

10.2.5 Total system error (TSE)

TSE is the system use error. $TSE = \sqrt{(NSE)^2 + (FTE)^2}$

10.2.6 Position estimation error (PEE)

Position estimation error is the difference between *true position* and *estimated position*.

10.3 Navigation systems

For RNP 10 authorisation, an aircraft operating in oceanic and remote areas must be equipped with at least two independent and serviceable Long Range Navigation Systems (LRNSs) comprising INS, IRS/FMS or GPS, of sufficient integrity such that the navigation system does not provide misleading information with an unacceptable probability.

11. AIRCRAFT GROUPS (FLEETS OF AIRCRAFT)

11.1 Definition of an aircraft group

For aircraft to be considered as members of a group for the purposes of RNP 10 authorisation, the following conditions must be satisfied:

- (a) the 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 10 navigational requirements.

- (b) the navigation system installed on each aircraft to meet the RNP 10 authorisation must be manufactured to the manufacturer’s same specifications and have the same part numbers;

Note: CASA may regard aircraft that have INSs/IRUs that are of a different manufacturer or part number as part of the group, if it is demonstrated to CASA that this navigation equipment provides equivalent navigational performance.

- (c) where an authorisation 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 10 navigational capabilities for the RNP 10 approved time duration; and
 - (iv) the engineering data to be used to ensure continued in-service RNP 10 capability for the RNP 10 approved time duration.

Note: Class II navigation is any en route operation that 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.

11.2 Definition of a non-group aircraft

A non-group aircraft is an aircraft for which an operator applies for authorisation 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 authorisation by another operator and may reduce the number of trials required to obtain an RNP 10 authorisation. Appendix 6 describes a sample data collection procedure and provides sample forms that can be used to collect the data.

12. DETERMINATION OF AIRCRAFT EQUIPMENT ELIGIBILITY

12.1 Introduction

It is important to note that the following groupings are different to the groupings discussed in Section 11 above. The groupings below are 'eligibility groups'. These groups have been established to assist in the discussion and do not have a precise definition. The definitions used are meant to assist in determining the approval method that may be used to authorise specific aircraft and navigation systems. Doppler systems will not be approved for RNP 10 operations.

12.2 Aircraft eligibility through RNP certification (Eligibility Group 1)

Group 1 aircraft are those that have obtained formal certification and approval of RNP integration in the aircraft.

12.2.1 RNP compliance

RNP compliance is documented in the AFM, and is typically not limited to RNP 10. The AFM will address RNP levels that have been demonstrated and any related provisions applicable to its use (e.g. navaid sensor requirements). Operational authorisation of Group 1 aircraft will be based upon the performance stated in the AFM.

12.2.2 Airworthiness authorisation

An operator may obtain an airworthiness approval specifically addressing RNP 10 performance. 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. The AFM Supplement must be submitted to CASA for approval, in accordance with CAR 55 and 55A. The layout of the AFM Supplement should follow the format for the AFM. The AFM should include the following wording, or similar.

The XXX navigation system has been demonstrated to meet criteria of FAA AC 20-138A as a primary means of navigation for flights up to YYY hours in duration without updating. The determination of flight duration starts when the system is placed in navigation mode.

For flights that include airborne updating of navigation position, the operator must address the effect that updating has on position accuracy, and associated time limits for RNP operations, pertinent to the updating navaid facilities used, and the area, routes, or procedures to be flown.

Demonstration of performance in accordance with the provisions of AC 91U-2(0) does not constitute authorisation to conduct RNP operations.

Note: The above wording in an AFM is based upon performance approval by CASA, and is only one element of the authorisation process. Aircraft which have had this wording entered into their flight manual will be eligible for authorisation if all other criteria are met. The YYY hours specified in the AFM does not include updating. When the operator proposes a credit for updating, the proposal must address the effects the updating has on position accuracy, and any associated time limits for RNP operations pertinent to the updating navaid facilities used, and the area, routes, or procedures to be flown.

12.3 Aircraft eligibility through prior navigation system certification (Eligibility Group 2)

Group 2 aircraft are those that can equate their certified level of performance, under previous standards, to the RNP 10 criteria. The standards listed in Sections 12.3.1 to 12.3.6 below can be used to qualify an aircraft under Group 2.

Other standards may also be used if they are sufficient to ensure that the RNP 10 requirements are met. If other standards are to be used, the applicant must propose an acceptable means of compliance.

CASA will revise this AC as new standards are developed for the basis of RNP 10.

12.3.1 Transport category aircraft equipped with dual FMSs, and other equipment, in accordance with Appendix 8

Aircraft equipped with INSS or IRUs, Radio Navigation Positioning Updating and Electronic Map Displays in accordance with Appendix 8 meet all of the RNP 10 requirements for up to 6.2 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 12.6 below for information on the adjustment factors for systems that are updated en route).

Note: The 6.2 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. This 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 10 NM each (e.g. 10 NM/1.6015 NM/hr = 6.2 hours).

12.3.2 Aircraft equipped with INSS or IRUs that have been approved in accordance with FAR Part 121, Appendix G

Inertial systems approved in accordance with FAR Part 121, Appendix G, meet RNP 10 requirements for up to 6.2 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 FAR Section 121.355 and Part 121 Appendix G, are applicable to an RNP 10 authorisation.

Crosschecking 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.

12.3.3 Aircraft equipped with dual INSS or IRUs approved to minimum navigation performance specification (MNPS) or approved for RNAV operations in Australia

Aircraft equipped with dual INSS or IRUs approved for MNPS or RNAV operations in Australia 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.

If systems are updated en route, the operator must show the effect that the accuracy of the update has on the time limit. Appendix 7 provides a description of an updating procedure.

Note: Section 12.5 provides information on acceptable procedures for operators that wish to increase the 6.2 hours time limitation specified.

12.3.4 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 meet the RNP 10 requirements without time limitations. The INS or IRU must be approved to FARs Part 121, Appendix G. The GPS must be TSO-C129a authorised as a minimum, 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 10 approval (see FAA AC 20-138A Appendix 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 CASA requirements.

12.3.5 Aircraft equipped with dual global positioning systems (GPSs) 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 FAA AC 20-138A Appendix 1, meet the RNP 10 requirements without time limitations.

The AFM(s) must show that a particular GPS installation meets the appropriate regulatory 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 10 authorisation (see FAA AC 20-138A Appendix 1 on GPS as a primary means of navigation in oceanic and remote areas).

Note: If predictions indicate that the maximum FDE outage time for the intended RNP 10 operation will be exceeded, then the operation must be rescheduled when FDE is available. Alternatively, RNP 10 must be predicated on another means of navigation.

12.3.6 Multi-sensor systems integrating GPS (with GPS integrity provided by receiver autonomous integrity monitoring (RAIM))

Multi-sensor systems integrating GPS with RAIM and FDE that are approved using the guidance of FAA AC 20-130A, Airworthiness Approval of Navigation or Flight Management Systems Integrating Multiple Navigation Sensors, or equivalent, meet RNP 10 requirements without time limitations. In this case, the INS or IRU must be approved in accordance with FAR Part 121 Appendix G.

12.4 Aircraft eligibility through data collection

A data collection program must address the appropriate navigational accuracy requirements for RNP 10. The data collection must ensure that the applicant demonstrates to CASA that the aircraft and navigation system provides the flight crew with navigation situational awareness relative to the intended RNP 10 route.

The data collection must also ensure that the flight crew have 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.

Two types of data collection methods are described in this AC:

- (a) the *sequential method* is a data collection program meeting the provisions of Appendix 1. This method allows the operator to collect data and plot it against the 'Pass-Fail' graphs to determine if the operator's aircraft system will meet the RNP 10 requirements for the length of time needed by the operator; and
- (b) 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 Appendix 6, (Periodic Method). The data collected is then analysed as described in Appendix 6 to

determine if the system is capable of maintaining RNP 10 for the length of time needed by the operator.

12.5 Obtaining authorisation for an extended time limit for INS or IRU systems

The baseline RNP 10 time limit for INS and IRU systems after the system is placed in the navigation mode is 6.2 hours, as detailed in Sections 12.3.1, 12.3.2 and 12.3.3. 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 12.2);
- (b) when an INS or IRU has been approved using an existing approval standard (as detailed in Sections 12.3.1, 12.3.2 and 12.3.3), an extended time limit may be established by an applicant presenting justifying data to CASA. Group approvals will be granted with appropriate restrictions if the data collected indicates that approval is warranted. A means of analysing the certification of IRU performance and amending the existing approval in aircraft documents is described in Appendix 2;
- (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 10 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; or
- (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 using the guidance shown in Appendixes 1 or 6.

12.6 Effect of en-route updates

An operator may extend their RNP 10 navigation capability time by en-route updates. 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 6.2 hours can gain 5.9 hours following an automatic DME/DME update);
- (b) automatic updating using DME/VOR = Baseline minus 0.5 hours; and
- (c) manual updating using a method similar to that contained in Appendix 7 or approved by CASA = Baseline minus one hour.

12.7 Conditions under which automatic radio position updating is acceptable for flight in airspace where RNP 10 is applied

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

- (a) the procedures for automatic updating are included in an operator's training program;

- (b) the operator has ensured that flight crews are knowledgeable of the updating procedures and of the effect of the update on the navigation solution; and
- (c) an acceptable procedure for automatic updating may be used as the basis for an RNP 10 authorisation for an extended time as indicated by data presented to CASA. 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.

12.8 Conditions under which manual radio position updating may be considered as acceptable for flight in airspace where RNP 10 is applied

If manual updating is not specifically approved, manual position updates are not permitted in RNP 10 operations. Manual radio updating is acceptable for operations in airspace where RNP 10 is applied provided that:

- (a) the procedures for manual updating are reviewed by CASA on a case-by-case basis. An acceptable procedure for manual updating is described in Appendix 7 and may be used as the basis for an RNP 10 authorisation for an extended time when supported by acceptable data;
- (b) the operator shows that updating procedures and training contain measures or 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 in-service operations. This factor must be considered when establishing the RNP 10 time limit for INSs or IRUs (see Section 12.6); and
- (d) CASA finds that the flight crew qualification syllabus is effective pilot training.

13. MINIMUM EQUIPMENT LIST (MEL)

If an *RNP 10 Operational Authorisation* is granted on the basis of a specific operational procedure (such as credit for triple-mix), operators must adjust the MEL and specify the required dispatch conditions through the appropriate CASA Airline/Area office.

14. CONTINUING AIRWORTHINESS (MAINTENANCE REQUIREMENTS)

The holder of the design approval, including either the type certificate (TC) or supplemental type certificate (STC) for each individual navigation system installation must furnish to CASA at least one set of complete Instructions for Continued Airworthiness, in accordance with Section 1529 of Parts 23, 25, 27 and 29 of the FARs, for the maintenance requirements for operations conducted in accordance with this AC.

15. OPERATIONAL REQUIREMENTS

15.1 Navigational performance

For RNP 10 operations, an aircraft must meet a cross-track keeping accuracy and along-track positioning accuracy no greater than +/-10 NM for 95% of the flight time.

15.2 Navigation equipage

Except as authorised by CASA, all aircraft undertaking RNP 10 operations must have at least two independent long-range navigation systems of sufficient integrity such that the navigation system does not provide misleading information.

15.3 Flight plan

CASA 91.850 requires that operators must indicate RNP 10 authorisation in an approved manner which complies with ICAO Doc 4444 (PANS-ATM) Appendix 2 Item 10: Equipment. The letter 'R' must be placed in 'Item 10 (Equipment)' of the flight notification, to indicate the pilot has:

- (a) reviewed the planned route of flight, including the route(s) to any alternate aerodrome(s), to identify the types of RNP involved;
- (b) confirmed that the operator and aircraft have been authorised by CASA for RNP operations; and
- (c) confirmed that the aircraft can be operated in accordance with the RNP requirements for the planned route of flight, including the route(s) to any alternate aerodrome(s).

Note: Requirements relating to the method to be used to indicate the actual authorisation type e.g. RNP 10, is described in the AIP.

15.4 Availability of nav aids

At dispatch or during flight planning, the operator must ensure that adequate navigation aids are available en route to enable the aircraft to navigate to RNP 10.

15.5 Route evaluation for RNP 10 time limits for aircraft equipped only with INSs or IRUs

As detailed in Section 12.6, an RNP 10 time limit must be established for aircraft equipped with INSs or IRUs. When planning RNP 10 operations, the operator must establish that the aircraft will comply with the time limitation on the routes that it intends to fly.

In making this evaluation, the operator must consider the effect of headwinds and, for aircraft not capable of coupling the navigation system or flight director to the autopilot, FTE. The operator may choose to make this evaluation on a one-time basis or on a per flight basis. The operator should consider the points listed in the following sub-sections in making this evaluation.

15.5.1 Route evaluation

The operator must establish the aircraft's capability to satisfy the RNP 10 time limit established for dispatch or departure into airspace where RNP 10 is applied.

15.5.2 Start point for calculation

The calculation must start at the point where the system is placed in the navigation mode or the last point at which the system is expected to be updated.

15.5.3 Stop point for calculation

The stop point may be one of the following:

- (a) the point at which the aircraft will begin to navigate by reference to ICAO Standard Nav aids (VOR, DME, NDB) and/or comes under radar surveillance from ATC; or
- (b) the first point at which the navigation system is expected to be updated.

15.5.4 Sources of wind component data

The operator may obtain the headwind component to be considered for the route from any source acceptable to the CASA. Acceptable sources for wind data include: the Bureau of Meteorology, National Weather Service, Bracknell, industry sources such as Boeing Winds on World Air Routes, and historical data supplied by the operator.

15.5.5 One time calculation based on 75% probability wind components

Certain sources of wind data establish the probability of experiencing a given wind component on routes between city pairs on an annual basis. If an operator chooses to make a one-time calculation of RNP 10 time limit compliance, the operator may use the annual 75% probability level to calculate the effect of headwinds (This level is a reasonable estimation of wind components.).

15.5.6 Calculation of time limit for each specific flight

The operator may choose to evaluate each individual flight using flight planned winds to determine if the aircraft will comply with the specified time limit.

If the operator determined that the time limit will be exceeded, the aircraft must fly an alternate route or delay the flight until the time limit can be met. This evaluation is a flight planning or dispatch task.

16. DISCUSSION OF CERTIFICATION ACTIONS RELATED TO RNP 10

16.1 Improved performance

An operator may elect to have the aircraft navigation performance certified to a new standard to take advantage of the aircraft capability. The aircraft may obtain credit for improved performance through operational data collection, in which case certification is not necessary.

The following paragraphs provide guidelines for different types of navigation systems. The applicant must propose an acceptable means of compliance for any systems not identified below.

16.1.1 Aircraft incorporating INS

For aircraft with INS certified under FAR Part 121, Appendix G, additional certification is only necessary for an operator who chooses to certify INS accuracy to better than 2 NM per hour radial error.

However:

- (a) the certification of INS performance must address all issues associated with maintaining the required accuracy including, accuracy and reliability, acceptance test procedures, maintenance procedures, and training programs; and
- (b) the applicant must identify the standard against which INS performance is to be demonstrated. This standard may be a regulatory (i.e. Appendix G), industry, or applicant unique specification. A statement must be added to the AFM identifying the accuracy standard used for certification (see Section 12.2.2).

16.1.2 Aircraft incorporating GPS

FAA AC 20-138A is an acceptable means of complying with installation requirements for aircraft that use GPS, but does not integrate it with other sensors. FAA AC 20-130A describes an acceptable means of compliance for multi-sensor navigation systems that incorporate GPS.

An operator who intends to use GPS as the only navigation system (e.g. no INS or IRS) for RNP 10 operations, must also comply with related CARs, AIP requirements and other State requirements, except for specific GPS requirements described in this AC.

16.2 Equipment configuration — MEL

The equipment configuration used to demonstrate the required accuracy must be identical to the configuration that is specified in the MEL.

16.3 Equipment configuration — accuracy

The equipment configuration used to demonstrate the required accuracy must be supportable in RNP 10 oceanic and remote airspace. For example, the statistical benefit of estimating position using INS position data filtered with DME data will not be considered by CASA as part of its review of an application for an RNP 10 operational authorisation.

16.4 Equipment installation — regulations

The design of the installation must comply with the design standards that are applicable to the aircraft being modified. The installation in an Australian registered aircraft must be performed in accordance with the applicable regulations.

Arthur White
Acting Group General Manager
Air Transport Operations Group

2 November 2005

APPENDIX 1**AIRCRAFT ELIGIBILITY THROUGH DATA COLLECTION****1. GENERAL**

This appendix offers broad guidance to Flying Operations (FO) Team Leaders in the use of a statistical procedure to determine whether aircraft should be approved for RNP 10 operations. FO Team Leaders should consider each application on its own merit, and should weigh such factors as the operator's experience, crew training procedures, the airspace in which error data are accumulated (e.g. NOPAC, CEPAC, US National Airspace System, MNPS airspace, Tasman Sea), and the age of the data. FO Team Leaders may request a review of the data by CASA navigation specialists.

RNP 10 authorisations will be issued for specific combinations of aircraft and navigation systems. If the navigation system which is a candidate for RNP 10 authorisation is an INS, IRS, or any other system whose accuracy decreases with increasing flight time, the authorisation must be limited to the number of hours during which the aircraft can be expected to satisfy both the lateral ('cross-track') and longitudinal ('along-track') accuracy criteria of RNP 10.

This appendix describes statistical tests that use data gathered from repeated flights. Invoking standard statistical terminology, the appendix refers to a flight trial. This means, for example, an aircraft with three INSs could provide three data points (trials per flight). In each trial the operator measures two errors:

- (a) the longitudinal position-determination error of the candidate navigation system;
and
- (b) the lateral deviation of the candidate aircraft from its planned route center line.

The longitudinal position-determination error measured in the i^{th} trial is called a_i ; the lateral deviation measured in the i^{th} trial is called c_i . In order for the statistical test to be valid, the data gathered in each trial must be independent of those gathered in any other trial. In other words, the outcome of each trial must not influence the outcome of any subsequent trial. Data will typically be gathered after an aircraft has flown for at least as long as the time for which operational authorisation is being requested, while being guided solely by the navigation system which is a candidate for RNP 10 operational authorisation.

An operator requesting *RNP 10 Operational Authorisation* for a candidate aircraft and navigation system must inform CASA of the flights during which it plans to collect error data. The operator should collect data on every eligible flight until the statistical procedure described in this appendix indicates that the data collection should cease. The operator must use all valid data, and, in particular, must not ignore data that show large errors while submitting only those that show small errors.

2. DATA COLLECTION GUIDELINES

Operators using the methods described in this appendix are to collect position estimates and use those estimates to compute the lateral and longitudinal errors of their aircraft. If a combination of aircraft and navigation system is a candidate for RNP 10 operational authorisation for a stated number of hours h , the data must be collected at least h hours after that navigation system was last updated or initialised. Furthermore, the data must be collected after the aircraft has been guided solely by that navigation system for a period long enough to eliminate the effects of prior guidance by any other navigation system that the aircraft may have used during its flight.

In order to determine the lateral and longitudinal error data, the operator must simultaneously obtain position estimates from:

- (a) the navigation system which is a candidate for RNP 10 operational authorisation (the candidate system); and
- (b) a reference system, which must be highly accurate in the area where the position is estimated (The estimate from the reference system is taken to represent the aircraft's actual position.).

The candidate system position and the reference system position must be measured simultaneously, at a time when the aircraft has been flying along a straight segment of its planned route for several minutes, and is expected to continue flying along that segment for several more minutes. The operator must ensure that the aircraft's actual position at the time of the measurement is due to guidance derived solely from the candidate system. In particular, the operator must ensure that no other navigation system (especially the reference system) contributed, to any significant extent, to the aircraft's position at the time of the measurement.

The operator is responsible for establishing that reference-system positions are accurate. The operator may wish to consider the following in selecting reference systems:

- (a) DME/DME positions taken within 200 NM of both DME stations derived automatically and displayed on systems such as Flight Management Computers (FMCs);
- (b) GPS derived positions; and
- (c) VOR/DME positions taken within 25 NM of the navigation aid.

Note: Operators considering the use of these systems are reminded that many of them are installed so that their outputs are automatically used to guide the aircraft. If any system other than the candidate system has significant influence on the aircraft's position at the time when position estimates are obtained, the test of the candidate system will not be valid.

The positions simultaneously reported by the candidate system and the reference system must both be expressed (or re-expressed) in terms of the same coordinate system.

The longitudinal error a_i is the distance between the position reported by the reference system and the position reported by the candidate system, measured along a line parallel to the planned route of flight. (So, if the two reported positions are connected by a vector, and the vector is resolved into a component parallel to the route and a component perpendicular to the route, a_i is the magnitude of the component parallel to the route). The lateral deviation c_i is the distance between the planned route of flight and the position reported by the reference system (Note that the position reported by the candidate system has no role in determining the value of c_i). The distances a_i and c_i must be absolute distances expressed in NM, i.e. expressed as non-negative numbers. In particular, longitudinal errors in opposite directions do not offset each other; nor do lateral deviations to the left and right offset each other.

Suppose, for example, that an operator wishes to obtain RNP 10 operational authorisation of an aircraft equipped with an INS, and that the RNP 10 time limit being sought for the INS is 6 hours. Suppose also that the aircraft can very accurately determine its position when it is in airspace with multiple DME coverage, and that it usually enters a large block of such airspace 5½ hours after last use of another navigation system or signal to adjust its INS output. On each occasion when:

- (a) the aircraft is flying in an area of multiple DME coverage;
- (b) at least 6 hours have passed since the last adjustment of INS output; and
- (c) the aircraft has been flying straight for several minutes, and is expected to continue flying straight for several more minutes;

the flight crew records: (a) the time; (b) the desired track (or just the ‘from’ and ‘to’ waypoints); (c) the position reported by the INS; and (d) the position reported by the multiple-DME system. The operator later computes the longitudinal error a_i and the lateral deviation c_i .

The following is a non-technical summary of the steps used in collecting, plotting, and analysing data collected for the purpose of using the pass-fail graphs in this appendix. The data collected indicates the difference between the aircraft’s navigation system and a highly accurate reference system. The position determined from the reference system is the aircraft’s actual position. The point at which this data should be taken is when first leaving Class II Navigation (see *Note* in paragraph 11.1 (c)) at the designation end of the flight.

- (a) Operator collects the following independent data on each eligible flight:
 - (i) on the desired flight path, the last waypoint and the to waypoint (these points should be taken from the flight plan);
 - (ii) the reference system (e.g. DME/DME) computed aircraft position; and
 - (iii) guidance system (e.g. INS) computed aircraft position for each system.

Note: (ii) and (iii) measurements should be taken simultaneously.

- (b) The data must be taken after the guidance system (candidate navigation system) has been operating without any external update for a time at least as long as the time limit being requested.

- (c) The data gathered in subparagraph (a), above, is now used to calculate:
- (i) cross-track error (lateral deviation - c_i); and
 - (ii) along-track error (longitudinal error - a_i).

Note: a_i in (ii), above, is considered to represent along-track error.

- (d) Cross-track Error (c_i). Calculate the perpendicular distance from the reference system computed aircraft position to the desired flight path (the desired flight path is a great circle line between the last waypoint and the 'to' waypoint).
- (e) Along-track Error (a_i). Calculate the distance between the reference system computed aircraft position and the guidance system (INS etc.) computed aircraft position along a line parallel to the desired flight path.
- (f) Cross-track Pass/Fail. Following the first flight, errors are summed (e.g. if the error was 2 NM on the first flight and 3 NM on the second flight then the cumulative error would equal 5). The cumulative error is the value of the ordinate ('y' coordinate in a Cartesian coordinate system) and the number of trials is the value of the abscissa ('x' coordinate in a Cartesian coordinate system). The intersection of these two is then plotted on Figure A1.1. The cross-track RNP 10 requirements are passed when the plots of the cumulative errors fall below the lower pass line or fail if they pass the upper fail line.
- (g) Along-track Pass/Fail. Following each flight, the errors are squared and following the first flight, the errors are summed (e.g. if the error was 2 NM on the first flight and 3NM on the second flight then the cumulative squared errors would equal $4 + 9 = 13$). The cumulative error squared is the value of the ordinate ('y' coordinate in a Cartesian coordinate system) and the number of trials is the value of the abscissa ('x' coordinate in a Cartesian coordinate system). The intersection of these two values is then plotted on Figure A1.2. The along-track RNP 10 requirements are passed when the plots of the cumulative errors squared fall below the lower pass line or fail if they pass above the upper fail line.

Operators planning to use their aircraft in a particular route system must gather error data from flights through that system (e.g. NOPAC, CEPAC, and Tasman Sea). If operations are planned for an area other than the one in which data are collected, the operator should show that navigational performance will not be degraded there.

The operator must develop a standard form on which to document each flight. It must include:

- (a) date;
- (b) departure aerodrome;
- (c) destination aerodrome;
- (d) aircraft type, series and registration (e.g. VH) number;
- (e) make and model of the candidate navigation system;
- (f) type of reference system used (e.g. VOR/DME, DME/DME);

- (g) time at which the candidate system is placed in navigation mode;
- (h) times (if any) at which the candidate system is updated while en route;
- (i) time at which positions are recorded from the candidate system and the reference system;
- (j) reference system position coordinates;
- (k) candidate system position coordinates; and
- (l) desired track or waypoints passed immediately before and after the recorded positions.

After the flight the operator computes the lateral deviation c_i and the longitudinal error a_i , as indicated above.

3. STATISTICAL PROCEDURES

3.1 Background

Sequential sampling procedures are used to determine whether a candidate aircraft and navigation system should receive RNP 10 operational authorisation. After each trial the operator recomputes certain statistics and compares them to numbers indicated below. The comparison will infer one of three possible results:

- (a) the candidate aircraft and navigation system satisfy the RNP 10 performance requirements, and the statistical test is terminated; or
- (b) the candidate aircraft and navigation system do not satisfy the RNP 10 performance requirements, and the statistical test is terminated; or
- (c) the operator needs to perform another trial (gather more data) and continue the statistical test, as it cannot yet reach a decision with the required level of confidence.

A sequential sampling procedure typically requires fewer trials than does a statistical test that has a fixed number of trials and has the same probability of making the correct decision. In general, the better an aircraft navigates, the fewer trials it will need to pass the test to demonstrate RNP 10 compliance.

However, for CASA to have sufficiently high confidence in the test results, even an aircraft that navigates perfectly will need to perform at least 13 trials in order to demonstrate that it meets the RNP 10 lateral containment criterion, and at least 19 trials to demonstrate that it meets the RNP 10 longitudinal accuracy criterion. An aircraft that navigates poorly will need relatively few trials before failing the test. The test has been designed so that the average number of trials needed for it to reach a decision is approximately 100.

3.2 Test of lateral conformance

To establish whether or not the navigation system meets the RNP 10 lateral containment criterion, the operator may use the mathematical process described in this paragraph, or use the graph shown in Figure A1.1 and described below.

After conducting at least 13 trials, the operator should add together all of the lateral deviations obtained up to that point.

Suppose, in particular, that n trials have been conducted. If the sum of lateral deviations does not exceed $2.968n - 37.853$, the candidate aircraft and navigation system have demonstrated compliance with the RNP 10 lateral containment criterion, and the operator should stop computing lateral deviation data.

If the sum of the lateral deviations equals or exceeds $2.968n + 37.853$, the candidate aircraft and navigation system have demonstrated that they do not meet the RNP 10 lateral containment criterion, and the operator should stop computing lateral deviation data.

If the sum of the lateral deviations is between $2.968n - 37.853$ and $2.968n + 37.853$, the test cannot yet yield a decision. The operator must perform another trial to obtain an additional lateral deviation. This new lateral deviation is added to the sum obtained previously, and the new sum is then compared to $2.968(n+1) - 37.853$ and $2.968(n+1) + 37.853$.

In other words, let $S_{c,n} = c_1 + c_2 + \dots + c_n$ be the sum of (the absolute values of) the lateral deviations obtained in the first n trials. If $S_{c,n} \leq 2.968n - 37.853$, the aircraft and its navigation system pass the lateral conformance test. If $S_{c,n} \geq 2.968n + 37.853$, the aircraft and its navigation system fail the lateral conformance test. If $2.968n - 37.853 < S_{c,n} < 2.968n + 37.853$, the operator must:

- (a) perform another trial to obtain c_{n+1} ;
- (b) compute $S_{c,n+1} = c_1 + c_2 + \dots + c_n + c_{n+1}$ ($= S_{c,n} + c_{n+1}$);
- (c) compare $S_{c,n+1}$ to $2.968(n+1) - 37.853$ and to $2.968(n+1) + 37.853$; and
- (d) determine whether the candidate aircraft and navigation system pass the test or fail the test, or whether an $(n + 2)^{th}$ trial is needed.

Figure A1.1 illustrates these rules for the lateral conformance test. The operator may wish to plot points on Figure A1.1 as lateral deviation data is collected. The abscissa (horizontal component) of each plotted point is n , the number of trials completed; and the ordinate (vertical component) of each point is $S_{c,n}$, the sum of the (absolute values of the) lateral deviations observed in the n trials.

The test ends as soon as a point falls into the lower right region or the upper left region of the graph. If a point is plotted in the lower right region, the candidate aircraft and navigation system have shown that they satisfy the RNP 10 lateral containment criterion. If a point is plotted in the upper left region the candidate aircraft and navigation system have demonstrated that they do not meet the criterion. Whenever a point is plotted in the middle region, the operator needs to accumulate more data.

In the event that the tests of $S_{c,n}$ do not yield a decision on the aircraft's lateral performance after 200 trials, the operator should perform the following computations:

- (a) compute the quantity $D_1 = c_1^2 + c_2^2 + \dots + c_{200}^2$;
- (b) compute the quantity $D_2 = \frac{S_{c,200}^2}{200} = \frac{(c_1 + c_2 + \dots + c_{200})^2}{200}$; and
- (c) compute the quantity $D_c^2 = \frac{D_1 - D_2}{200}$.

If D_c^2 does not exceed 18.649, the aircraft and navigation system satisfy the RNP 10 lateral containment criterion. If D_c^2 does exceed 18.649, the aircraft and navigation system do not meet the criterion, and do not qualify for RNP 10 operational authorisation.

3.3 Test of longitudinal accuracy

To establish whether or not the navigation system can meet the RNP 10 longitudinal accuracy criterion, the operator may use the mathematical process described below, or use the graph provided in Figure A1.2.

After conducting at least 19 trials, the operator should add together the squares of all the longitudinal errors obtained up to that point.

Suppose, for example, that n trials have been conducted. If the sum of the squares of the longitudinal errors does not exceed $22.018n - 397.667$, the aircraft and navigation system have demonstrated compliance with the RNP 10 longitudinal accuracy requirement, and the operator should stop computing longitudinal error data.

If the sum of the squares of the longitudinal errors exceeds $22.018n + 397.667$, the aircraft and navigation system have demonstrated that they do not meet the RNP 10 longitudinal accuracy requirement, and the operator should stop computing longitudinal error data.

If the sum of the squares of the longitudinal errors is between $22.018n - 397.667$ and $22.018n + 397.667$, the test cannot yield a decision. The operator must perform another trial to obtain an additional longitudinal error. The square of this new longitudinal error is added to the sum obtained previously, and the new sum is then compared to $22.018(n+1) - 397.667$ and to $22.018(n+1) + 397.667$.

In other words, let $S_{a,n} = a_1^2 + a_2^2 + \dots + a_n^2$ be the sum of the squares of the longitudinal errors obtained in the first n trials. If $S_{a,n} \leq 22.018n - 397.667$, the aircraft and its navigation system pass the longitudinal accuracy test. If $S_{a,n} \geq 22.018n + 397.667$, the aircraft and its navigation system fail the longitudinal accuracy test. If $22.018n - 397.667 < S_{a,n} < 22.018n + 397.667$, the operator must:

- (a) perform another trial to obtain another longitudinal error a_{n+1} ;
- (b) compute $S_{a,n+1} = a_1^2 + a_2^2 + \dots + a_n^2 + a_{n+1}^2$ ($= S_{a,n} + a_{n+1}^2$);
- (c) compare $S_{a,n+1}$ to $22.018(n+1) - 397.667$ and to $22.018(n+1) + 397.667$; and
- (d) determine whether the candidate aircraft and navigation system pass the test or fail the test, or whether an $(n + 2)^{th}$ trial is needed.

Figure A1.2 illustrates the rules for the sequential test of longitudinal accuracy. The operator may wish to plot points on Figure A1.2 as longitudinal error data are collected. The abscissa (horizontal component) of a plotted point is n , the number of trials completed; and the ordinate (vertical component) of a point is $S_{a,n}$, the sum of the squares of the longitudinal errors observed in the n trials. The test ends as soon as a point falls into the lower right region or the upper left region of the graph.

If a point is plotted in the lower right region, the candidate aircraft and navigation system have shown that they satisfy the RNP 10 longitudinal accuracy criterion.

If a point is plotted in the upper left region, the aircraft and navigation system have demonstrated that they do not meet that criterion. Whenever a point is plotted in the middle region, the operator needs to accumulate more data.

In the event that the sequential sampling procedure described above does not yield a decision on the aircraft's longitudinal performance after 200 trials, the operator should perform the following computations:

(a) compute the quantity $D_3 = \frac{(a_1 + a_2 + \dots + a_{200})^2}{200}$; and

(b) compute the quantity $D_a^2 = \frac{S_{a,200} - D_3}{200}$.

If D_a^2 does not exceed 21.784, the aircraft and navigation system satisfy the RNP 10 longitudinal accuracy criterion. If D_a^2 does exceed 21.784, the aircraft and navigation system do not meet the criterion, and do not qualify for RNP 10 operational authorisation.

SOURCE: FAA Order 8400.12A

Figure A1.1: Acceptance, Rejection, and Continuation Regions for Sequential Test of Lateral Conformance

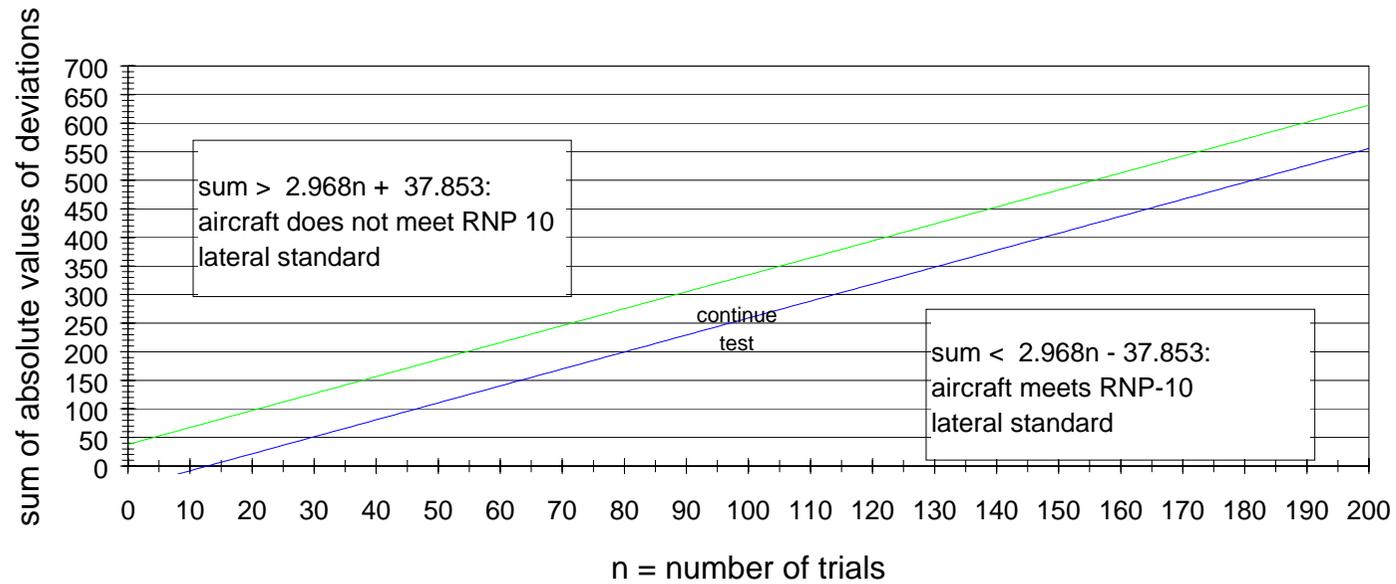
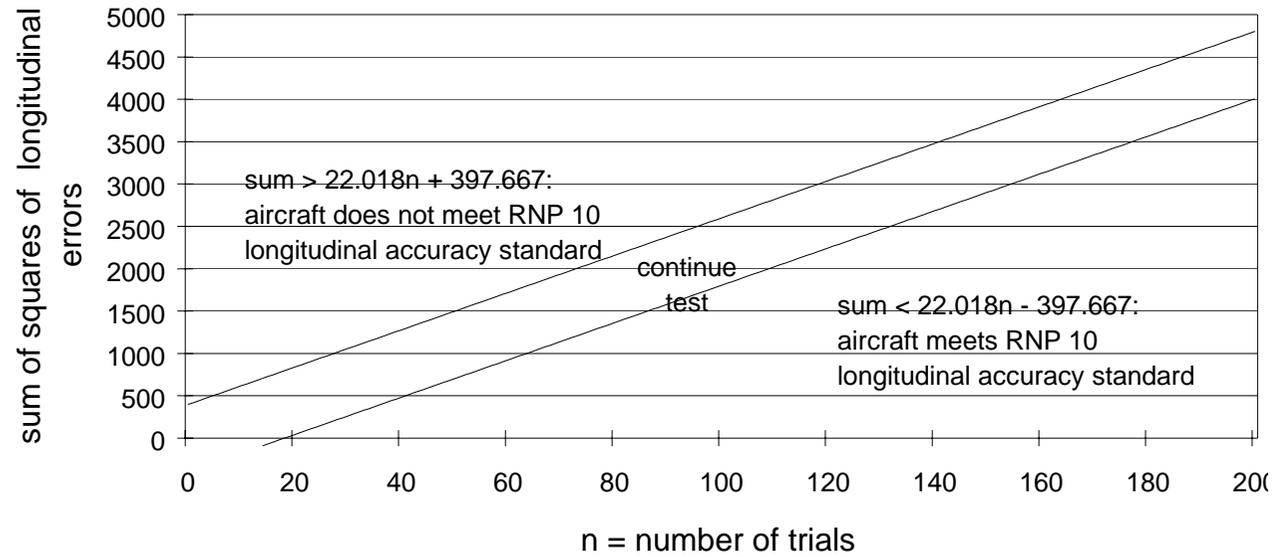


Figure A1.2: Acceptance, Rejection and Continuation Regions for Sequential Test of Longitudinal Accuracy



APPENDIX 2**CERTIFICATION OF IRU PERFORMANCE****1. GUIDELINES AND ASSUMPTIONS**

IRUs that meet the current requirements of FAR Part 121, Appendix G, meet all of the RNP 10 requirements for up to 6.2 hours of flight time without radio position updating. IRU accuracy, reliability, training, and maintenance issues that are required by Appendix G, are part of the aircraft certification. However, IRU manufacturers believe that the actual performance of some types of IRUs exceeds the current Appendix G requirements. A methodology for analysing IRU performance, combined with requirements to update IRU manufacturer's Specification Control Drawings (SCD), Acceptance Test Procedures (ATP), and airline IRU maintenance/removal criteria is described in the following section.

2. CERTIFICATION GUIDELINES

IRU accuracy and reliability must be analysed in conjunction with the flight management system interface. An analysis performed on a specific manufacturer's aircraft model is not necessarily applicable to other aircraft operating the same equipment. However, other aircraft may be analysed using the same or equivalent methodology as proposed herein.

- (a) The Radial Navigation Error Distribution for IRUs is Modelled by a Rayleigh Distribution. The 95% statistic of radial position error will be used when demonstrating compliance. It is assumed that cross-track and along-track errors are Gaussian, independent, and have equal variances.
- (b) The Radial Position Error will be Evaluated for the Range of the Independent Time Variable (time in navigation), as certified for the IRU navigation maximum time (e.g. 18 hours).
- (c) Time-Dependent Position Error Data will be Presented. Other non-inertial error sources will not be considered as part of the IRU certification (i.e. flight technical error). Therefore, the maximum time duration of flight operations in RNP 10 airspace will be evaluated and determined as part of the authorisation.
- (d) The Assessment of Navigation Performance may Employ System Analysis, IRU Error Modeling (Covariance Analysis), and System Simulation. Analytical findings may be validated with empirical data from laboratory testing and aircraft flight testing, as applicable.

When credit is required for IRU performance that is superior to the original certification, the existing IRU specification control drawings for the IRU Type Designs must be revised to account for the new tighter tolerance system error budgets. If it has been determined that all IRUs for a given part number meet the minimum requirements of the new performance standard, then the IRU part number may remain the same.

When only some of the IRUs for a given part number meet the minimum requirements of the new performance standard, then screening is required and part number updates will be required to identify the IRUs which are compliant to the new performance standard.

The AFM or AFM Supplement (AFMS) must be modified to reflect the certification of IRUs to tighter accuracy requirements. The AFM should provide sufficient time-

dependent information so that the maximum time in RNP 10 operations can be assessed as part of the operational authorisation.

In addition, production and field acceptance test procedures will require an update by the supplier, to ensure that the installed IRU meets the tighter accuracy tolerance required.

Operator maintenance procedures will require updating to ensure appropriate monitoring of IRU performance to the new requirements contained in this AC, and replacement of IRUs on aircraft that do not meet the navigation performance of these new criteria.

Procedures for flight operations must be identified and applied to ensure IRU alignment before extended range flights and time-in-navigation for the intended time duration of flight in RNP 10 airspace.

SOURCE: FAA Order 8400.12A

APPENDIX 3-A**SAMPLE LETTER OF REQUEST FOR
'RNP 10 OPERATIONAL AUTHORISATION'**

File Reference

Team Leader Flying Operations
Civil Aviation Safety Authority
(Address)

Dear Sir

APPLICATION FOR RNP 10 OPERATIONAL AUTHORISATION

(Aircraft operator) requests that an *RNP 10 Operational Authorisation* be granted to enable it to conduct RNP 10 operations with a maximum time of (number) hours between navigation system updates.

The following (aircraft operator) aircraft meet the requirements stated in MOS Subpart 91.U Chapter 3 and listed in AC 91U-2(0) for RNP 10 operations.

AIRCRAFT TYPE/SERIES	NAVIGATION EQUIPMENT	RNP 10 TIME LIMIT
B747-400	List all nav equipment (e.g. VOR, DME, VHF NAV, GPS, IRS, FMS, ADC etc) by name and type/manufacturer/model	Number of hours or unlimited
B767-	As above	As above
B737-	As above	As above
F900C etc	As Above	As above

Flight crews have been trained in accordance with the standards stated in MOS Subpart 91.U Chapter 3 and listed in AC 91U-2(0).

Yours sincerely

Signature
(Name)
(Appointment/Title)
(Date)

APPENDIX 3-B

SAMPLE 'RNP 10 OPERATIONAL AUTHORISATION'

**OPERATIONS IN AIRSPACE WHERE REQUIRED NAVIGATION
PERFORMANCE 10 (RNP 10) APPLIES**

RNP 10 Operational Authorisation Number XXX/04

I,, Team Leader Flying Operations,
.....Airline/Area Office, am satisfied that the following operator, aircraft
and navigation systems meet the requirements for RNP 10 operations, with the stated RNP
10 time limit, in accordance with CASR 91.U.4.

Operator: (ACN)

Aircraft: Serial Number

Registration:

NAVIGATION EQUIPMENT

TYPE	MFG.	Part No.	Model No.
FMS NCU (2)	Universal	1116-40-1110	UNS-1K
ADC (2)	Honeywell	7014700-920	AZ-850
VHF NAV (2)	Honeywell	066-01067-0004	KN-53

RNP 10 Time Limit:

For and on behalf of the Civil Aviation Safety Authority

Name:

Position/Title:

Airline/Area Office:

Date:

APPENDIX 4**TRAINING PROGRAMS, OPERATING PRACTICES AND PROCEDURES****1. INTRODUCTION**

The following items (detailed in Sections 2 to 5) should be standardised and incorporated into training programs and operating practices and procedures. Certain items may already be adequately standardised in existing operator programs and procedures. New technologies also may eliminate the need for certain crew actions. If this is found to be the case by CASA, then the intent of this appendix can be considered as being met.

Note: This material has been written for a wide variety of operator types and, therefore, certain items that have been included may not apply to all operations.

2. FLIGHT PLANNING

During flight planning, the flight crew must pay particular attention to conditions that may affect RNP 10 operations. These include, but may not be limited to:

- (a) verifying that the aircraft is authorized for RNP 10 operations;
- (b) that the RNP 10 time limit has been accounted for;
- (c) verifying that the letter 'R' is annotated in Field 10 of the ICAO Flight Plan; and that any other requirements concerning flight plan notification have been met e.g. notification of the RNP type (Note: such requirements are described in the AIP);
- (d) confirming the requirements for GPS, such as FDE, if appropriate for the operation; and
- (e) if required for a specific navigation system, accounting for any operating restriction related to RNP 10 operational authorisation.

3. PRE-FLIGHT PROCEDURES

The following actions must be completed during pre-flight:

- (a) review maintenance logs and forms to ascertain the condition of equipment required for RNP 10 operations. Ensure that maintenance action has been taken to correct defects to required equipment;
- (b) during the external inspection of aircraft, where possible, particular attention must be paid to the condition of navigation antennae and the condition of the fuselage skin in the vicinity of each of these antennae (This check may be accomplished by a qualified and authorised person other than the pilot, e.g. a flight engineer or a maintenance person.); and
- (c) emergency procedures for RNP 10 operations are the same as normal oceanic emergency procedures with one exception - crews must be able to recognise (and ATC must be advised accordingly) when the aircraft is no longer capable of navigating in accordance with its RNP 10 operational authorisation requirements.

4. EN-ROUTE

At least two long-range navigation systems capable of navigating to RNP 10 must be operational at entry to the airspace where RNP 10 operations are to be conducted

Before entering OCA or remote airspace, the aircraft's position must be checked as accurately as possible by using external nav aids. This may require DME/DME and/or DME/VOR checks to determine navigation system errors through displayed and actual positions. If the system is updated, the proper procedures must be followed with the aid of a prepared checklist.

Operator in-flight operating drills must include mandatory crosschecking procedures to identify navigation errors in sufficient time to prevent aircraft from deviating inadvertently from ATC cleared routes.

Crews must advise ATC of any deterioration or failure of the navigation equipment below the navigation performance requirements or of any deviations required for a contingency procedure.

5. FLIGHT CREW KNOWLEDGE

AOC holders must ensure that flight crews have been trained to ensure that crews are knowledgeable of the topics contained in this AC, the limits of their RNP 10 navigation capabilities, the effects of updating navigation systems, and RNP 10 contingency procedures.

Private operators must show CASA that pilots are knowledgeable on RNP 10 operations. This AC provides suitable guidance material.

APPENDIX 5**CHECKLIST FOR THE RNP 10 AUTHORISATION APPLICATION PROCESS****1. ACTIONS BY OPERATOR****1.1 Preparation of an application package as described in section 9****1.2 Familiarisation with documentation**

Operators should become familiar with Sections 8 and 9 of this AC before contacting the appropriate CASA Airline/Area office. These sections provide the criteria for authorisation by placing aircraft/navigation systems in groups. An understanding of Sections 8 and 9 provides the operator with an indication of how much time might be required in obtaining an authorisation. Group I approvals are administrative and can be granted as quickly as CASA workloads permit. Group II approvals may be made quite rapidly or may take longer depending upon the aircraft/navigation system configurations. Group III approvals will usually involve an extended time for evaluation and an authorisation may or may not be granted.

1.3 Pre-application meeting

The operator should schedule a pre-application meeting with the appropriate CASA Airline/Area office well before the authorisation is actually needed.

1.4 Formal application for authorisation

The operator should submit a formal application for an *RNP 10 Operational Authorisation* in accordance with the requirements outlined in this AC and discussed in the pre-application meeting. The application must be made in writing in a manner similar to that shown in Appendix 3-A.

1.5 Crew training

RNP 10 airspace is a special airspace. There are no legal requirements for private operators to have specific training programs for RNP 10 operations. However, ICAO rules demand that States ensure that flight crews are qualified to operate in special airspace. Thus, private operators will be required to satisfy CASA that they are qualified.

1.6 Receipt of authorisation

Once the application has been approved, CASA will issue an *RNP 10 Operational Authorisation* to enable the operator to undertake RNP 10 operations. Flight crews are authorised to perform RNP 10 operations for the time authorised within the parameters established for their navigation system configuration.

2. ACTIONS BY FLYING OPERATIONS INSPECTOR (FOI)

FOI CHECK LIST

APPLICANT	SECTION	FOI INIT.	DATE
1. FOI familiarisation with the authorisation process	Section 8.		
2. Set up meeting date	Section 8.2		
3. Application meeting: FOI <ul style="list-style-type: none"> • Applicant's understanding of AC 91U-2(0) • Check of documentation <ul style="list-style-type: none"> – RNP time requested for specific route or area of operation – Airworthiness documentation – 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 program – RNP 10 operations issues – RNP 10 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 <ul style="list-style-type: none"> • Choose one of the following as a means by which authorisation will be accomplished: <ul style="list-style-type: none"> – The operator has an AFM entry or other documentation from a CASA Airworthiness Branch/Officer granting certification approval for RNP 10 or better for a specific time period (eligibility group 1). – Plan on authorising the operator for unlimited RNP 10 navigation if either one or both of the required LRNSs is a GPS and the unit(s) are integral to the primary steering instrument of the mandatory flight crew. GPS approval guidance is contained in FAA AC 20-138A Appendix 1. – Authorise the operator for the RNP value and time specified in the AFM. – Authorise the operator for RNP 10 for 6.2 hours based upon Appendix 8 of this AC. 	Section 12 Section 12.2		

FOI CHECK LIST
(Continued)

	SECTION	FOI INIT.	DATE
<p>5. Evaluate Operator's LRNSs (continued)</p> <ul style="list-style-type: none"> • FARs Part 121, Appendix G (eligibility group 2) asks operator if authorisation of additional time will be needed. <u>If 'Yes'</u>, then a discussion of one of the extended time procedures will be required. <ul style="list-style-type: none"> – Request that operational navigation performance data be presented (eligibility group 3). – Determine if the operator has updating procedures. <u>If 'Yes'</u>, 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. <u>If 'No'</u>, then advise operator that a data collection program based on one of the following will be required prior to granting authorisation (eligibility group 3): <ul style="list-style-type: none"> <i>Sequential sampling</i> based on Appendix 1 of AC 91U-2(0). <i>Periodic data collection</i> based upon a portable GPS being used for a baseline (see Appendix 6) or data collection based upon the radial error determined from destination gate positions. 	Section 12.3		
	Section 12.4		
	Sections 12.5 & 12.6		
	Appendix 1 Appendix 6		
<p>6. Data Analysis Meeting</p> <ul style="list-style-type: none"> – Check all data required and discussed at the application meeting. – 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'. – If data collection was required, examine it closely. If any doubt exists as to the validity or integrity of the data, contact one of CASA's navigation specialists. 	Appendixes 1 & 6		
	Appendix 4		
<p>7. Issue RNP 10 Operational Authorisation to the Operator</p>	Appendix 3-B		

APPENDIX 6

A SAMPLE DATA COLLECTION PROCESS (PERIODIC METHOD)

1. INTRODUCTION

This section describes data collection procedures that are approved by CASA on the basis of analysis of the data and multiple validation flights.

There are two methods in which data may be collected. 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 crewmember. Only authorised flight crews may operate the navigation system. Although no technical specifications are stated for the GPS unit used, operators should 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.

The second method uses a single, un-updated 'gate position' as a data point and performing the calculations at the end of this appendix to determine an RNP 10 limit.

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. Operators wishing to use 'gate position' only do not need to use the data pages but can go directly to the destination data page and record the gate position data and time since last update.

2. GENERAL INSTRUCTIONS

2.1 GPS updating

Pilots should not update the INS to a GPS position. Doing so would invalidate the data collected.

2.2 Data recording

When recording data, all times are in 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.

2.3 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.

2.4 INS initialisation

Refer to page 1 of DATA PAGES following this section and:

- (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'; and
- (e) check if updating is by radio navigation of position, 'Yes' or 'No'.

2.5 Times

Refer to page 1 of DATA PAGES following this section and:

- (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; and
- (d) record IN (at the gate) time.

2.6 Destination gate positions

Refer to pages 4 and 5 of the DATA PAGES following this section and:

- (a) pilots should not remove INS updates until INS updated / triple-mix positions are recorded at the gate;
- (b) record the destination gate number, published position, the number of GPS SVs (Satellite Vehicles) in view, GPS DOP and EPE values, and GPS position;
- (c) record INS updated / triple-mix positions;
- (d) remove INS updates;
- (e) record INS un-updated positions and INS distances from the gate position; and
- (f) INS data should be recorded in the Maintenance Log as usual.

2.7 Half hourly position readings

Refer to page 2 and beyond of DATA PAGES following this section and:

- (a) once each 30 minutes after take-off (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); and
- (h) release the frozen INS and GPS positions.

2.8 En-route INS updates

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

Use this section only if manual updating is being evaluated and:

- (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; and
- (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; and
 - (ii) record the GPS position.

2.9 Radio navigation INS updates

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

Use this section only if manual updating is being evaluated (e.g. ground based radio navigation positions are used for INS updates) and record:

- (a) navaid identifiers;
- (b) aircraft position derived from ground navaids (update position);
- (c) time of update;
- (d) INS position before update; and
- (e) GPS position.

DATA PAGES

Flight No. _____ UTC Departure Date _____ Departure Aerodrome _____

A/c Type _____ Registn. No. _____ Arrival Aerodrome _____ Captain _____

INS INITIALISATION

- (a) 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):

- (b) INS initialisation coordinates (published or GPS): N / S
 E / W
- (c) Triple-mix selected? *Yes* *No*
- (d) Radio navigation updating? *Yes* *No*

TIMES

OFFZ
 Time NAV mode selectedZ
Time in NAV mode before take-offHrsMins
 Time entering Class II nav airspaceZ
 Approx time leaving Class II nav airspaceZ
 Time NAV mod selectedZ
Approx time in NAV mode
before leaving Class II airspaceHrs.....Mins
 INZ
 Time NAV mode selectedZ
Total time in NAV modeHrs.....Mins

DATA PAGE 1

DATA PAGES

Flight No. _____ UTC Departure Date _____ Departure Aerodrome _____

A/c Type _____ Registr. No. _____ Arrival Aerodrome _____ Captain _____

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 / S	
			E / W	
NEXT WAYPOINT		NAME	N / S	
			E / 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 / S	
			E / W	
NEXT WAYPOINT		NAME	N / S	
			E / W	

DATA PAGE 2

DATA PAGES

Flight No. _____ UTC Departure Date _____ Departure Aerodrome _____

A/c Type _____ Registn. No. _____ Arrival Aerodrome _____ Captain _____

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 / S E / W
NEXT WAYPOINT		NAME		N / S E / W

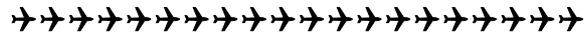
DATA POINT 4		Z	Altitude	
GPS	No. of SV	DOP	EPE	
GPS Position	N / S		E / W	
Updated / Triple-Mix Positions			Un-Updated Positions	
		INS 1		
		INS 2		
		INS 3		
LAST WAYPOINT		NAME		N / S E / W
NEXT WAYPOINT		NAME		N / S E / W

DATA PAGE 3

DATA PAGES

Flight No. _____ UTC Departure Date _____ Departure Aerodrome _____

A/c Type _____ Registr. No. _____ Arrival Aerodrome _____ Captain _____



Note: Copy previous pages for use in collecting data points in excess of 4 as needed to collect data for the total flight hours. Use the procedures following the destination data pages to analyse the data.

COMPLETE DESTINATION DATA ON NEXT PAGE

DATA PAGE 4

DATA PAGES

Flight No. _____ UTC Departure Date _____ Departure Aerodrome _____

A/c Type _____ Registn. No. _____ Arrival Aerodrome _____ Captain _____

DESTINATION GPS / INS POSITIONS

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

(a) Destination Gate No.

(b) Published Position N / S

E / W

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

DATA PAGE 5

3. RNP 10 DATA REDUCTION TECHNIQUES FOR PERIODIC IN-FLIGHT METHOD OF DATA COLLECTED

- (a) Collect reference data (GPS) and INS/IRU data at least 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.

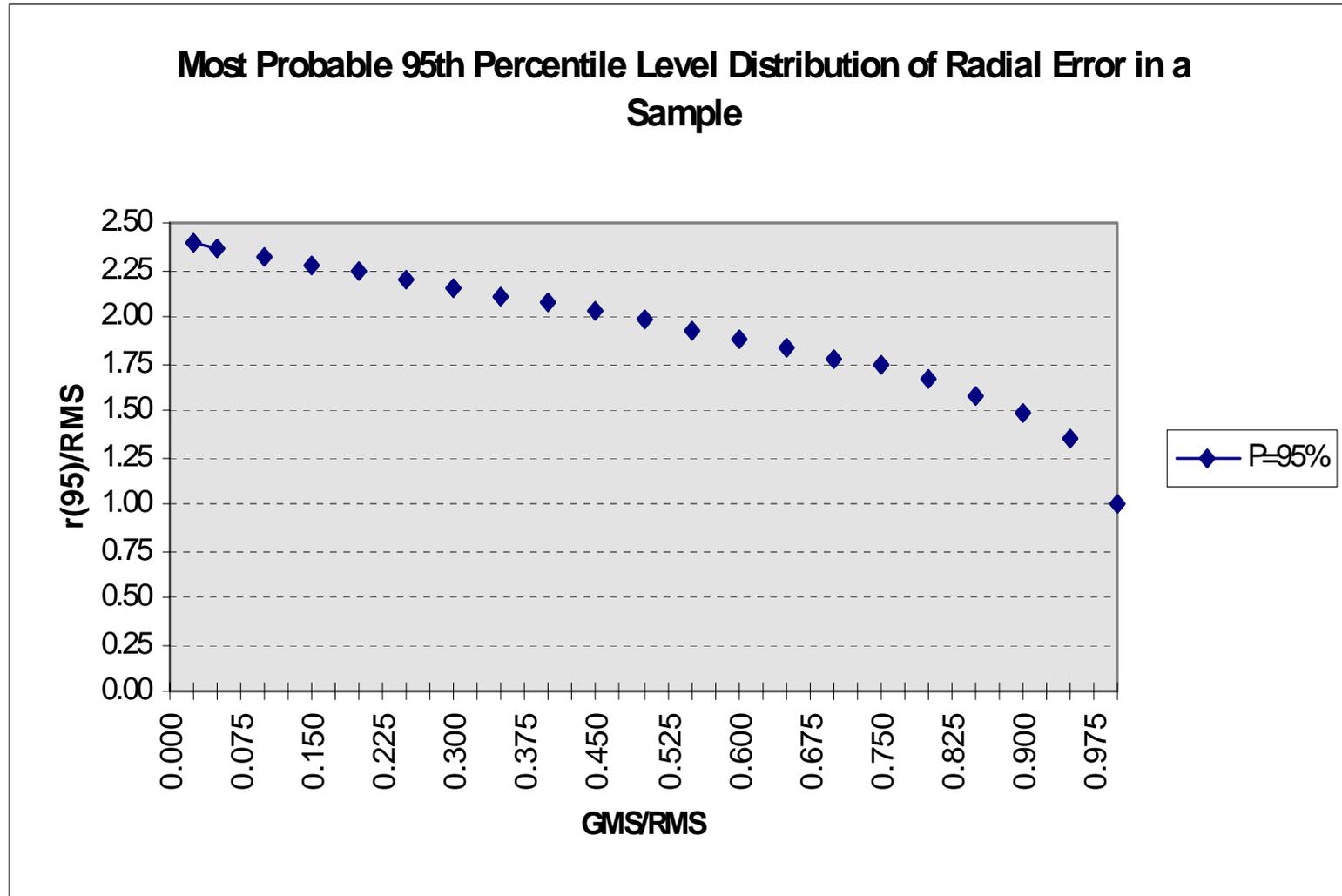
$$RMS = \left(\frac{1}{n} \sum_{i=1}^{i=n} r_i^2 \right)^{1/2}$$

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

where: r = radial error at elapsed time point; and n = number of observations of radial error at equally spaced time intervals.

- (h) Using the P=95 curve from Figure A6.1 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 10 NM defines maximum flight time wherein the navigation system meets RNP 10 criteria.

Figure A6.1



4. 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 Table A6.2 should be used.

The symbols used in the figures below are:

r = radial error

r^2 = square of the radial error

$\prod r$ = product of radial errors

Σ = Sum

Σr^2 = Sum of the squares of the radial errors

Table A6.1: 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 (\prod) of radial errors (column 2) = 320,360

The sum of the radial errors squared (Σr^2) (column 3) = 530.63

Calculations

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

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

$$\text{RATIO} = \text{GM}/\text{RMS} = 8.27/9.40 = 0.88$$

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

Thus $r_{(95)}/\text{RMS} = 1.47$ (for this example).

The ordinate is defined as $r_{(95)}/\text{RMS}$:

where $r_{(95)} = 95$ percentile of error.

Now $r_{(95)}$ for the data in the example is determined from the following:

$$r_{(95)} = \text{Ordinate value (for the data)} \times \text{RMS} = 1.47 \times 9.40 = 13.8 \text{ NM.}$$

These results indicate that the 95 percentile level of error at 10 hours is 13.8 NM which is greater than the required 10 NM and the system would not qualify for RNP10 for 10 hours based on the data presented.

Guidance on gate position data collection is shown below.

Table A6.2: Table of Radial Errors (Use for Gate Position Data)

Note: No data are provided for this method. Calculations would be made identical to the procedure used in Table A6.1.

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

- (a) The product ($\mathbf{\Pi}$) of radial errors (column 3) = _____
- (b) The n^{th} route of $\mathbf{\Pi}$ = _____ = GM
- (c) The sum of the radial errors squared ($\sum r^2$) (column 4) = _____
- (d) The square route of $\left(\frac{1}{n} \sum r_i^2 \right)$ = _____ = RMS

After calculating (2) and (4) use Table A6.1 to determine $r_{(95)}$. Multiply this factor by the RMS to determine the drift in NM. If this value is less than 10 NM then the navigation system can be approved for RNP 10 for the time in nav of this flight. Note that this is the data for one flight only. Data should be collected in the same manner and in an equal time length for a minimum of 20 flights.

SOURCE: FAA Order 8400.12A

APPENDIX 7**AN APPROVED MANUAL UPDATING PROCEDURE FOR
RNP 10 OPERATIONS****1. INTRODUCTION**

In order to facilitate RNP 10 operations for airborne navigation systems that are unable to achieve RNP 10 performance for greater than 6.2 hours, the following methods of manual position updating are suggested as a means to extend the 6.2 hours.

Manual position updating is 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 GPS 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 in accordance with FAA AC 20-138A Appendix 1 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; and
- (d) the flight crew must have in its possession a plotting chart with the information specified in this Appendix.

2. MANDATORY DATA REQUIRED TO ACCOMPANY ALL OF THE UPDATING METHODS (REQUIRED FOR EACH FLIGHT ALONG WITH COPY OF THE PLOTTING CHART)

INS INITIALIZATION

(a) 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):

.....

.....

.....

(b) INS initialisation coordinates (published or GPS): N / S.....
E / W.....

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

(d) Radio navigation updating? *Yes No*

TIMES

- PRIOR TO TAKE-OFF
OFFZ
Time NAV mode selectedZ
Time in NAV mode before take-offHrs.....Mins
- FLIGHT PHASE
Time entering Class II nav airspaceZ
Approx time leaving Class II nav airspaceZ
Time NAV mod selectedZ
Approx time in NAV mode
before leaving Class II airspaceHrs.....Mins
- ARRIVAL PHASE
INZ
Time NAV mode selectedZ
Total time in NAV modeHrs.....Mins

3. TRAINING

AOC holders intending on using manual updating procedures must ensure that every flight crew using the procedures is trained in the updating procedures. The operator must be able to demonstrate that it has a reliable method of having its crews perform the update, and which should be approved by the operator's Airline/Area office Team Leader Flying Operations to determine if the method is acceptable. Operators must update training manuals to include the procedures and these will be evaluated by the CASA as a part of the authorisation process.

Private operators intending on using manual updating procedures must provide evidence to CASA that crews using the procedures are capable of maintaining the same standards as commercial operators.

4. METHOD 1: MANUAL UPDATING BASED ON CROSSING A FIX ALONG A 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 must be at least 50 NM.
- (b) The flight crew must 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 must note the distance from the VOR/DME or TACAN facility and mark it on the plotting chart. The flight crew must also note the inertial positions of each of the operating INS. The crew must 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 10 clock for an additional predetermined time.
- (c) To accomplish this manual update, the flight crew must 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/TACAN radial used to define the fix. Each fix must 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 must 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 or TACAN facility. Crews must 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.

Note: This type of manual updating would be applicable when operating along several of the routes that pass in the vicinity of SHEMA VOR such as R220, W460, R-341, A-590, A-342, R-451 and R-336.

5. METHOD 2: MANUAL UPDATING WHEN FLYING A ROUTE THAT IS DEFINED BY A VOR/DME OR TACAN FACILITY

- (a) The accuracy of a manual update when over flying a VOR/DME or TACAN 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 or TACAN. These fixes must 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 or TACAN 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 must 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 10 performance based on evaluation of the position checks.

6. METHOD 3: USING AN IFR APPROVED GPS INSTALLATION AS AN UPDATING REFERENCE

- (a) Using Method 3 the update is performed by comparing the INS position to the GPS position at a chosen waypoint.
- (b) Prior to departure the mandatory data must be logged.
- (c) Updating requirements are:
 - (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; and

- (vi) if the data indicate that RNP 10 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 affect future flights. Additionally, this information can be used in a response to a *CASA Navigation Error Investigation Form*. The requirements are:
 - (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 (FOM airport 10-7 page or airport plan view);
 - (viii) INS data should be recorded in the Maintenance Log as usual; and
 - (ix) release the frozen INS positions.

SOURCE: FAA Order 8400.12A

APPENDIX 8

TRANSPORT CATEGORY AIRCRAFT EQUIPAGE

Aircraft equipped with Flight Management Systems (FMSs) with barometric Vertical Navigation (VNAV), oceanic, en route, terminal, and approach capability meet all of the RNP 10 requirements for up to 6.2 hours of flight time. 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; FAA AC 20-130A, Airworthiness Approval of Navigation or Flight Management Systems Integrating Multiple Navigation Sensors; or equivalent criteria as approved by CASA;
- (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; and
- (e) an electronic map.

Note: The above have been taken from the US Aeronautical Information Manual (AIM), Table 5-1-2 Aircraft Equipment Suffixes - Area Navigation Systems. Under the US system, these aircraft would qualify for the /E suffix.

INTENTIONALLY LEFT BLANK