U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
National Policy

ORDER 8400.12C

Effective Date:
11/9/11

SUBJ: Required Navigation Performance 10 (RNP 10) Operational Authorization

1. Purpose of This Order. This order provides policy and direction for obtaining operational authorization for Required Navigation Performance 10 (RNP 10). This order provides guidance on aircraft eligibility and RNP 10 operational authorization. The order enables an applicant to be approved as capable of meeting the navigation element requirements when RNP 10 is specified. The order does not address communications or surveillance requirements that may be specified to operate on a particular route or in a particular area. Those requirements are specified in other documents, such as the Aeronautical Information Publications (AIP) and the International Civil Aviation Organization (ICAO) Regional Supplementary Procedures document (Doc 7030).

2. Audience. This order applies to aviation safety inspectors (ASI).

3. Where You Can Find This Order. You can find this order on the MyFAA employee Web site at https://employees.faa.gov/tools_resources/orders_notices. Inspectors can access this order through the Flight Standards Information Management System (FSIMS) at http://fsims.avs.faa.gov. Air carriers (operators) can find this order on the Federal Aviation Administration's (FAA) Web site at http://fsims.faa.gov. This order is available to the public at http://www.faa.gov/regulations_policies/orders_notices.

4. Cancellation. This order cancels FAA Order 8400.12B, Required Navigation Performance 10 (RNP 10) Operational Authorization, dated January 29, 2010.

5. Background.

a. Ocean and Remote Area Operations. RNP 10 and Required Navigation Performance 4 (RNP 4) are the only RNP navigation specifications (NavSpecs) currently applicable to oceanic and remote area operations. Other Area Navigation (RNAV) and RNP NavSpecs are applicable to continental en route, terminal area, and approach operations.

b. ICAO Efforts. States and operators are implementing RNAV and RNP NavSpecs as part of a worldwide ICAO effort to implement Performance-based Navigation (PBN) and communication, navigation, surveillance, and air traffic management (CNS/ATM) concepts.

(1) RNP 10 and 50-nautical mile (NM) lateral separation were implemented first in 1998 in the North Pacific (NOPAC) route system. Implementation in additional Pacific oceanic areas proceeded over the next 2 years.

(2) RNP 10 and 50-NM lateral separation is also currently applicable on the following:

- Routes in the European-South American Corridor;
- Routes between Santiago, Chile and Lima, Peru;
- The West Atlantic Route System (WATRS) and parts of the San Juan and Miami Oceanic Control Areas;
- Some routes connecting Australia, Asia, and Europe; and
- The Gulf of Mexico, where single long-range navigation system (S-LRNS) RNP 10 is authorized; i.e., the Houston oceanic control area (CTA)/flight information region (FIR) and the portion of the Miami CTA/FIR overlying the Gulf of Mexico, Monterrey CTA, and Merida High CTA within the Mexico FIR/upper control area (UTA).

c. Required NavSpecs. The NavSpecs required for the application of 50-NM lateral and 50-NM longitudinal separation is RNP 10. Fifty-NM longitudinal separation also requires enhanced communications and surveillance capabilities. ICAO Annex 6, Part I, Chapter 7, and Part II, Chapter 2 call for authorizations to be obtained from the State of Operator and/or the State of Registry, as appropriate, before conducting RNP 10 operations. For U.S. operators, see operations specification (OpSpec)/management specification (MSpec)/letter of authorization (LOA) B036, Class II Navigation Using Multiple Long-Range Navigation Systems, for all RNP 10 areas of operations, or see OpSpec/MSpec/LOA B054, Class II Navigation Using Single Long-Range Navigation System (S-LRNS), for S-LRNS in the Gulf of Mexico.

d. ICAO PBN Manual. RNP 10 is addressed in the ICAO PBN Manual (Doc 9613), Volume II, Implementing RNAV and RNP, Part B, Implementing RNAV. RNP 10 does not require performance monitoring and alerting onboard the aircraft. RNP 10 is being retained as the designation of the NavSpec because it is in common use worldwide.

e. Other Separation Standards. Different oceanic separation standards may require different RNP NavSpecs. For example, 30-NM lateral separation requires RNP 4 authorization in compliance with the current edition of FAA Order 8400.33, Obtaining Authorization for Required Navigation Performance 4 (RNP 4) Oceanic and Remote Area Operations. Operators with RNP 4 authorization should not be required to reapply for approval to conduct Class II Navigation in areas requiring RNP 10 authorization.

6. Related Regulations and Publications.

a. Title 14 of the Code of Federal Regulations (14 CFR):

- Part 121 Appendix G.
- Part 91 Subpart H.

b. FAA Documents (current editions):

(1) Advisory Circulator (AC) 20-138, Airworthiness Approval of Positioning and Navigation Systems.

(2) FAA RNP Authorization Job Aids. FAA RNP 10 Authorization Job Aids are currently posted on FAA Web pages. You can access these Web pages by going to the FAA home page (http://www.faa.gov) and searching for:

- Gulf of Mexico 50 (NM) Lateral Separation Reduction Initiative (http://www.faa.gov/about/office_org/headquarters_offices/ato/service_units/enroute/oceanic/gomex);
- West Atlantic Route System (WATRS) Route Restructure and Separation Reduction (http://www.faa.gov/about/office_org/headquarters_offices/ato/service_units/enroute/oceanic/watrs_plus/); or
- Pacific Comm/Nav/Surveillance (CNS) Requirements/Options (http://www.faa.gov/about/office_org/headquarters_offices/ato/service_units/enroute/oceanic/pacific_cns).

(3) FAA Order 7110.82, Reporting Oceanic Errors.

(4) FAA Order 8900.1, Volume 4, Chapter 1, Air Navigation, Communications, and Surveillance.

(5) Technical Standard Order (TSO)-C115b, Airborne Area Navigation Equipment Using Multi-Sensor Inputs.

(6) TSO-C129a, Airborne Supplemental Navigation Equipment Using the Global Positioning System (GPS).

(7) TSO-C145c, Airborne Navigation Sensors Using the Global Positioning System Augmented by the Satellite Based Augmentation System.

(8) TSO-C146c, Stand-Alone Airborne Navigation Equipment Using the Global Positioning System Augmented by the Satellite Based Augmentation System.

(9) TSO-C196, Airborne Supplemental Navigation Sensors for Global Positioning System Equipment Using Aircraft-Based Augmentation.

c. Other Documents.

(1) Copies of the ICAO PBN Manual (Doc 9613) may be obtained from Document Sales Unit, ICAO, 999 University Street, Montreal, Quebec, H3C 5H7, Canada.

(2) ICAO Regional Supplementary Procedures (SUPPS) (Doc 7030).

(3) Aeronautical Information Publications (AIP).

(4) Copies of the following may be purchased online at http://naco.faa.gov/ecomp, or from the FAA, National Aeronautical Charting Office (NAC), Distribution Division (AJW-3550), 10201 Good Luck Road, Glenn Dale, MD 20769-9700:

- United States Government Flight Information Publication—Chart Supplement—Alaska.
- United States Government Flight Information Publication—Chart Supplement—Pacific.

(5) Copies of RTCA DO-236B, Minimum Aviation System Performance Standard: Required Navigation Performance for Area Navigation, RTCA, may be purchased from RTCA, Inc., 1828 L Street, NW, Suite 805, Washington, DC 20036. You can also purchase it online at http://www.rtca.org/onlinecart/index.cfm.

(6) Copies of the Aeronautical Information Manual (AIM) may be purchased from the U.S. Government Printing Office (GPO), P.O. Box 979050, St. Louis, MO 63187-9000. An up-to-date electronic copy is also currently available on the Internet at http://www.faa.gov/air_traffic/publications/atpubs/aim.

7. Applicability.

a. All Operators. This guidance applies to all operators conducting operations under 14 CFR parts 91, 121, 125, and 135.

b. Requirements. The requirements are consistent with part 91, § 91.703(a)(1) and (2), which require each certificate holder operating a civil aircraft of U.S. registry outside of the United States to comply with ICAO Annex 2 when over the high seas and to comply with the regulations of a foreign country when operating within that country's airspace.

8. Operational Authorization—General.

a. Requirements.

(1) To obtain operational authorization, operators must show that—

- Aircraft/navigation systems are eligible for RNP 10 operations,
- Flightcrew members have procedures for the navigation systems to be used,
- Flightcrew members are knowledgeable on operational policy applicable to the area of operations to be flown, and
- Maintenance requirements applicable to long-range navigation systems (LRNS) are acceptable.

(2) An RNP 10 Authorization Job Aid is posted on FAA Web pages such as Gulf of Mexico 50 (NM) Lateral Separation Reduction Initiative (http://www.faa.gov/about/office_org/headquarters_offices/ato/service_units/enroute/oceanic/gomex), West Atlantic Route System Restructure and Separation Reduction (http://www.faa.gov/about/office_org/headquarters_offices/ato/service_units/enroute/oceanic/watrs_plus), and Pacific Comm/Nav/Surveillance (CNS) Requirements/Options (http://www.faa.gov/about/office_org/headquarters_offices/ato/service_units/enroute/oceanic/pacific_cns).

b. Authorization Documents. An appropriate OpSpec, MSpec, or LOA, as applicable, may be issued through the Web-based Operations Safety System (WebOPSS).

9. Operational Authorization Process. RNP 10 requires that appropriate FAA offices must determine that each individual aircraft is qualified and authorize the individual operator before the operator conducts RNP 10 operations. The following paragraphs provide application guidelines for operators desiring to obtain RNP 10 operational authorizations.

a. Preapplication Meeting. Each individual operator should schedule a preapplication meeting with either the certificate-holding district office (CHDO), certificate management office (CMO), or the Flight Standards District Office (FSDO), whichever is applicable. The intent of this meeting is—

- To inform the operator of FAA expectations in regard to RNP 10 approval,
- To discuss the contents of the operator's application,
- For the FAA to review and evaluate the application, and
- To discuss conditions for removal of the operational approval.

b. Contact Offices. Operators seeking RNP 10 operational authorization should contact FAA offices as follows:

(1) Parts 121, 125, and 135 Operators. Parts 121, 125, and 135 operators should notify the CHDO or CMO that holds its operating certificate of its intent to request approval for RNP 10 operations. RNP 10 authorizations for air carriers/operators will be addressed through issuance of approved OpSpecs. The OpSpecs will identify any necessary conditions or limitations (e.g., navigation systems or procedures required and RNP 10 time limits, if applicable). A sample letter of request for an air carrier to obtain RNP 10 operational approval is provided in Appendix C, Figure C-1, Sample Letter of Request.

(2) Part 91 Operators, Part 91 Subpart K (Part 91K) Program Managers, and Part 125 Letter of Deviation Authority (LODA) Holders. Part 91 operators and part 91K program managers should contact their local FSDO to start the process for RNP 10 authorization. Operators conducting operations under part 91 will be authorized RNP 10 through the issuance of an LOA. Part 91K program managers will be issued an MSpec. The authorization will identify any necessary conditions or limitations (e.g., navigation systems or procedures required and RNP 10 time limits, if applicable). ASIs can administratively issue an authorization to any General Aviation (GA) operator that meets the requirements of this order. MSpecs/LOAs should be issued through WebOPSS.

(3) Determining Eligibility of Aircraft for RNP 10. Many aircraft and navigation system types currently in use in oceanic or remote area operations will qualify for RNP 10 based on one or more provisions of existing certification criteria. Thus, additional aircraft certification action may not be necessary for the majority of RNP 10 authorizations. In these instances, additional aircraft certification will only be necessary if the operator chooses to claim additional performance beyond that originally certified or stated in the Aircraft Flight Manual (AFM) and if the operator cannot demonstrate the desired performance through data collection. See paragraph 12.

10. Application.

a. Contents of the Operator's RNP 10 Application.

(1) Eligibility Airworthiness Documents. Sufficient documentation should be available to establish that the aircraft has an appropriate AFM and Aircraft Flight Manual Supplement (AFMS), if applicable, and is otherwise suitably qualified to fly the intended routes (e.g., long-range navigation (LRN), communication).

(2) Description of Aircraft Equipment. The applicant should provide a configuration list that details pertinent components and equipment to be used for LRN and RNP 10 operations.

(3) RNP 10 Time Limit for Inertial Navigation Systems (INS) or Inertial Reference Units (IRU) (if applicable). The applicant should provide the RNP 10 time limit for which the applicant's INS or IRU system has been approved (see paragraph 13). In addition, the applicant should consider the effect of headwinds in the area of operations in which it intends to carry out RNP 10 operations (see paragraph 16).

(4) Operating Practices and Procedures and Training Programs.

(a) Air carriers/operators/program managers should submit training syllabi and other source training material to the FAA to show that the operational practices and procedures and training items related to RNP 10 operations are incorporated in various training programs, where applicable (e.g., initial, upgrade, recurrent). Training for other personnel should be included where appropriate (e.g., dispatchers, maintenance). Practices and procedures in the following areas should be standardized using the guidelines of Appendix D:

- Flight planning;
- Preflight procedures at the aircraft for each flight;
- Procedures before entry into an RNP 10 route or airspace; and
- In-flight, contingency, and flightcrew member qualification procedures.

(b) Part 91 operators should confirm that they will operate using the practices and procedures identified in Appendix D. Appendix D, subparagraph 5b contains guidance on the acceptability of part 91 operator flightcrew member knowledge.

(5) Operational Manuals and Checklists.

(a) Parts 121, 125, and 135 Operators. The appropriate manuals and checklists should be revised to include information/guidance on standard operating procedures (SOP) detailed in Appendix D. Appropriate manuals should include navigation equipment operating instructions and any procedures established to operate in a specific area of operations (e.g., contingency procedures). Manuals and checklists should be submitted for review as part of the application process.

(b) If the part 135 certificate holder has no operations manual they should incorporate Appendix D RNP 10 operating practices and procedures into one of the following:

- A stand-alone operations manual, or
- A section of the operator's application for RNP 10 authorization.

(c) Part 91 Operators. Part 91 operators should incorporate Appendix D RNP 10 operating practices and procedures into one of the following:

- A stand-alone operations manual, or
- A section of the operator's application for RNP 10 authorization.

(6) Past Performance. The applicant should include its operating history in the application. The applicant should address any events or incidents within the previous 5 years related to Class II navigation errors for that operator (e.g., gross navigational errors (GNE)) and identify those that have been rectified by changes in training, procedures, maintenance, or the aircraft/navigation system that is to be used.

(7) Minimum Equipment List (MEL). If the applicant operates under an MEL, the applicant should provide any MEL revisions necessary to address the RNP 10 provisions of this guidance (e.g., if approval is based on triple-mix, then the MEL must reflect that three navigation units must be operating).

(8) Maintenance. The applicant will provide document references, if any, for periodic testing, inspection, or maintenance requirements prescribed for LRNSs.

b. Evaluation of Application, Conditions for Removal of Authorization, and Error Reports.

(1) FAA Review and Evaluation of Applications. Once the application has been submitted, the FAA will begin the process of review and evaluation. If the content of the application is insufficient, the FAA will request additional information from the operator. When all the airworthiness and operational requirements of the application are met, the CHDO, CMO, FSDO, or International Field Office (IFO) will issue the appropriate OpSpecs, MSpecs, or LOAs for operational approval to conduct RNP 10 operations.

(2) Investigation of Navigation Errors. Demonstrated navigation accuracy provides the basis for determining the lateral spacing and separation necessary for traffic operating on a given route. Accordingly, lateral and longitudinal navigation errors are investigated to prevent their reoccurrence. Radar or satellite Automatic Dependent Surveillance-Contract (ADS-C) observations of each aircraft's proximity to the centerline and altitude are typically noted by Air Traffic Organization (ATO) facilities. If an observation indicates that an aircraft was not within an established limit, the reason(s) for the apparent deviation from centerline or altitude may need to be determined and steps taken to prevent a recurrence.

(3) Removal of RNP 10 Authorization. FAA Order 7110.82 establishes GNEs and height errors (HE). When appropriate, the FAA may consider these reports in determining remedial action. Repeated GNE or HE occurrences attributed to a specific piece of navigation equipment may result in withdrawal of OpSpecs/MSpecs or rescinding an LOA for use of that equipment. Information that indicates the potential for repeated errors may require a modification of an operator's training program. Information that attributes multiple errors to a particular flightcrew member may necessitate additional training, retesting, or airman certification review.

11. RNP 10 Requirements.

a. Cross-Track and Along-Track Error. All aircraft conducting RNP 10 operations will have a 95 percent cross-track error (XTK) of less than 10 NM. This includes positioning error, Flight Technical Error (FTE), path definition error, and display error. All aircraft will also have a 95 percent along-track positioning error of less than 10 NM.

Note: For RNP 10 approval, navigation positioning error is considered the dominant contributor to cross-track and along-track error. FTE, path definition error, and display error are considered to be insignificant for the purposes of RNP 10 approval. (RNP 10 is intended for oceanic and remote areas where aircraft separation minima on the order of 50 NM are applied.)

b. Error Types. When using the method of Appendix A for approval, the following error types are included. For the data collection method described in Appendix E, however, they are not included since the Appendix E method is more conservative. The Appendix E method uses radial error instead of cross-track and along-track error.

(1) FTE. The 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 errors.

(2) Path Definition. This is the difference between the defined path and the desired path at a specific point and time.

(3) Display Errors (Display System Error).

(a) 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.

(b) 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; 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.

(4) Navigation System Error (NSE). This is the root sum square of the ground station error contribution, the airborne receiver error, and the display system contribution.

(5) Total System Error (TSE). This is system use error. The formula for determining TSE is: $TSE = \sqrt{(NSE)^2 + (FTE)^2}$.

(6) Position Estimation. This is the difference between true position and estimated position.

c. RNP 10 Operation in Oceanic and Remote Areas. Aircraft must be equipped with at least dual navigation systems except for operation in the Gulf of Mexico where S-LRNS RNP 10 is authorized. The navigation system(s) shall have integrity such that the navigation system does not provide misleading information.

12. Aircraft Groups (Operator Aircraft Fleets).

a. Definition of an Operator Aircraft Group. For aircraft to be considered as members of a group for purposes of an operator obtaining RNP 10 approval, they should satisfy the following conditions:

(1) Aircraft should 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 utilize the database from the parent configuration to minimize the amount of additional data required to show compliance. The extent of 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 navigation requirements.

(2) The navigation system installed on each aircraft to meet the minimum RNP 10 approval should be manufactured to the same manufacturer specifications and should have the same part numbers.

(3) Where operating authority is sought for an aircraft group, the application package must contain the following information:

(a) A list of the aircraft group/LRNS combination(s) to which the application applies.

(b) For aircraft groups for which INS or IRU systems are the only source of LRN, the applicable RNP 10 time limit (see paragraph 13).

Note: Aircraft that have INS/IRUs that are of a different manufacturer or part number may be considered part of the group if it is demonstrated that this navigation equipment provides equivalent navigation performance.

b. Definition of a Non-Group Aircraft. An aircraft for which the operator applies for approval on the characteristics of the unique airframe and navigation system used, rather than on a group basis. For non-group aircraft where airworthiness approval has been based on data collection, the continuing integrity and accuracy of the navigation system is demonstrated by the same amount of data collection as is required for group aircraft.

Note: Data collected by one or more operators may be used as the basis for approval by another operator and may reduce the number of trials required to obtain approval. Appendix E describes a sample data collection procedure and provides sample forms to be used to collect the data.

13. Determining Aircraft Eligibility.

Note: The following paragraphs discuss eligibility groups. The information in this paragraph is provided to aid in determining the eligibility of LRNSs for RNP 10 operations.

a. Aircraft Eligibility through RNP Certification (Eligibility Group 1). Group 1 aircraft are those that have obtained approval from Aircraft Certification Offices (ACO) for RNP integration into aircraft navigation systems.

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

(2) An airworthiness approval specifically addressing RNP 10 performance may be obtained. The following is an example of wording for use in AFMs when RNP 10 approvals are granted by ACOs for a change in the INS/IRU certified performance:

(a) "The XXX navigation system has been demonstrated to meet criteria of FAA Order 8400.12, current edition, as a primary means of navigation for flights up to XXX hours in duration without updating. The determination of flight duration starts when the system is placed in the navigation mode."

(b) "For flights which include airborne updating of navigation position, the operator must address the effect that updating has on position accuracy, and any associated time limits for RNP operations, pertinent to the updating NAVAID facilities use, and the area, routes, or procedures to be flown."

(c) "Demonstration of performance in accordance with provisions of FAA Order 8400.12 does not constitute approval to conduct RNP operations."

Note: The above wording in an AFM is based upon performance approval by the FAA Aircraft Certification Service (AIR). It is only one element of the approval process. Aircraft that have had this wording entered into their flight manual will be eligible for operational approval through issuance of OpSpecs/MSpecs or an LOA, if all other criteria are met. The "XXX hours" specified in the AFM for INS and IRU systems does not include updating. When the operator proposes a credit for updating, the proposal must address the effect the updating has on position accuracy, and any associated time limits for RNP operations pertinent to the updating NAVAID facilities' use, and the area, routes, or procedures to be flown.

b. 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 subparagraphs 12b(1)–(5) 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 CHDO, CMO, or FSDO should consult with the Flight Technologies and Procedures Division (AFS-400) to determine the appropriate operational approval and limitations. As new standards are used for the basis of RNP 10, this order will be revised to reflect the new standards.

(1) Aircraft Equipped with Two or More INSs or IRUs Approved in Accordance with Part 121 Appendix G. Inertial systems approved in accordance with part 121 appendix G are considered to 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.

(a) If systems are updated en route, the 6.2 hour RNP 10 time limit must be adjusted to account for the accuracy of the update.

(b) INS accuracy, reliability, training, and maintenance issues that are required by part 121 appendix G are considered to be applicable to an RNP 10 authorization, including any associated Class II navigation procedures. Except as authorized by the Administrator in accordance with the applicable section of 14 CFR, at least dual equipage of eligible INS systems is required. Currently applicable references are § 121.351; part 125, § 125.203; and part 135, § 135.165.

Note: The consideration to use 6.2 hours of flight time is based on an inertial system with a 95 percent radial position error rate (circular error rate) of 2.0 NM/hour, which is statistically equivalent to individual 95 percent cross-track and 95 percent along-track position error rates (orthogonal error rates) of 1.6015 NM/hour each, and 95 percent cross-track and 95 percent along-track position error limits of 10 NM each (e.g., 10 NM/1.6015 NM/hour=6.2 hours).

(2) Aircraft Equipped with Two or More INSs or IRUs Approved for North Atlantic Minimum Navigation Performance Specification (NAT/MNPS) or Australian RNAV Operations. Aircraft equipped with dual INSs or IRUs approved for NAT/MNPS operations or RNAV operations in Australia can be considered to meet RNP 10 requirements for up to 6.2 hours after the system is placed in the navigation mode.

Note: Subparagraph 13d provides information on acceptable procedures for operators that desire to increase the specified 6.2 hours of flight time.

(3) Aircraft Equipped with Two or More GPSs. Aircraft approved to use GPS for oceanic and remote operations without reliance on other LRNSs are considered to meet the RNP 10 requirements without time limitations.

(a) The flight manual should indicate if a particular GPS installation meets the appropriate FAA requirements for oceanic and remote operations. Dual TSO-approved GPS equipment is required, and an approved dispatch fault detection and exclusion (FDE) availability prediction program must be used.

1. TSO-C196 and TSO-C145/TSO-C146( ) GPS equipment are inherently capable of supporting oceanic and remote operation when used in conjunction with an approved FDE prediction program.

2. TSO-C129( ) GPS equipment is not inherently capable of oceanic and remote operations. Additional criteria defining an acceptable means of compliance (AMC) for this equipment to be approved for this operation is located in AC 20-138, appendix 1.

(b) Multisensor systems integrating GPS with FDE approved using the guidance contained in AC 20-138 can be considered to meet RNP 10 requirements without time limitations.

(c) AC 20-138 provides an acceptable means of complying with installation requirements for aircraft using a GPS that is not integrated with other sensors.

(d) The maximum allowable time for which FDE capability is projected to be unavailable is 34 minutes. The maximum outage time should be included as a condition of the RNP 10 approval.

Note: If predictions indicate that the maximum FDE outage for the intended RNP 10 operation cannot be met, then the operation must be rescheduled when FDE is available, or RNP 10 must be predicated on an alternate means of navigation.

(4) Aircraft Equipped with a Single INS/IRU *and* a Single GPS Approved for Oceanic and Remote Operations. Aircraft equipped with a single INS or IRU and a single GPS meet the RNP 10 requirements without time limitations.

(a) The INS or IRU equipment must meet the standards of subparagraph 13b(1), except that only one INS/IRU is required.

(b) GPS equipment must meet the standards of subparagraph 13b(3), except that only one GPS is required.

(5) Aircraft Equipped With a Single INS/IRU or a Single GPS. Aircraft equipped with a single INS/IRU or a single GPS are approved for oceanic and remote navigation in the Houston oceanic CTA/FIR, the Gulf of Mexico portion of the Miami oceanic CTA/FIR, the Monterrey CTA, and Merida High CTA within the Mexico FIR/UTA. Aircraft equipped with GPS meet the RNP 10 requirements without time limitations.

Note: This approval is predicated on the air traffic surveillance provided in the Gulf of Mexico. Therefore, RNP 10 authorizations approved in accordance with this paragraph must clearly state that RNP 10 operational approval is limited to the Gulf of Mexico.

(a) INS or INU equipment must meet the standards of subparagraph 13b(1), except that only one INS/IRU is required.

(b) GPS equipment must meet the standards of subparagraph 13b(3), except that only one GPS is required.

c. Aircraft Eligibility through Data Collection (Eligibility Group 3). A data collection program should address appropriate navigation accuracy requirements for RNP 10. The data collection must ensure that the applicant demonstrates to the FAA that the aircraft and navigation system provide the flightcrew member with navigation situational awareness (SA) relative to the intended RNP 10 route. The data collection must also ensure that a clear understanding of the status of the navigation system is provided, and that failure indications and procedures are consistent with maintaining the RNP. This order describes two types of data collection: a sequential and a periodic data collection method.

(1) The sequential method is a data collection program that meets the provisions of Appendix A. This method allows the operator to collect data and plot it against the pass-fail graphs to determine if the operator's system will meet RNP 10 requirements for the length of time needed by the operator.

(2) The periodic method of data collection employs the use of a hand-held GPS receiver as a baseline for collected INS data, described in Appendix E. The collected data is then analyzed as described in Appendix E to determine if the system is capable of maintaining RNP 10 for the length of flight desired by the operator.

d. Obtaining Approval 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 subparagraphs 13b(1)–(3). This time limit may be extended by one of the following methods:

(1) An extended time limit may be established when RNP is integrated into the aircraft navigation system through a formal certification process (as described in subparagraph 13a).

(2) When an INS or IRU has been approved using an existing approval standard (as detailed in paragraphs 13b(1)–(3)), an extended time limit may be established by an applicant presenting justifying data to the appropriate ACO. Group approvals will be granted by aircraft certification with appropriate restrictions if the collected data indicates that approval is merited.

(3) 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 is required for parts 121, 125, and 135 dispatch or for part 91 takeoff for flight on RNP 10 routes. If the mixing or averaging function is not available at dispatch, 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 subparagraph 13d(4).

(4) When an INS or IRU has been approved using an existing approval standard, operators can establish an extended time limit by conducting a data collection program in accordance with the guidance provided in Appendix A or Appendix E.

e. Effect of En Route Updates. Operators may extend their RNP 10 navigation capability time by updating. Approvals for various updating procedures are based on the baseline for which they have been approved minus the time factors shown below:

(1) Automatic updating using distance measuring equipment (DME)/DME=baseline-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).

(2) Automatic updating using DME/very high frequency (VHF) omnirange station (VOR)=baseline-0.5 hours.

(3) Manual updating using a method similar to that contained in Appendix F or approved by AFS-400=baseline-1 hour.

f. Conditions Under Which Automatic Radio Position Updating May be Considered Acceptable for Flight in Airspace Where RNP 10 is Required. Automatic updating is considered to be any updating procedure that does not require crews to manually insert coordinates. Automatic updating may be considered acceptable for operations in airspace where RNP 10 is applied, provided that—

(1) Procedures for automatic updating are included in an operator’s training program.

(2) Crews are knowledgeable of the updating procedures and of the effect of the update on the navigation solution.

(3) An acceptable procedure for automatic updating may be used as the basis for an RNP 10 authorization for an extended time, as indicated by data presented to the principal operations inspector (POI) or ASI. 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.

g. Conditions Under Which Manual Radio Position Updating May be Considered Acceptable for Flight in Airspace Where RNP 10 is Required. If manual updating is not specifically approved, manual position updates are not permitted in RNP 10 operations. Manual radio updating may be considered acceptable for operations in airspace where RNP 10 is applied provided that—

(1) AFS-400 reviews procedures for manual updating on a case-by-case basis. An acceptable procedure for manual updating is described in Appendix F and may be used as the basis for an RNP 10 authorization for an extended time when supported by acceptable data.

(2) The operator shows that updating procedures and training contain measures for cross-checking to prevent blunder errors and that the crew qualification curriculum provides effective pilot training.

(3) The operator provides data that establishes the accuracy with which the aircraft navigation system can be updated using manual procedures and representative NAVAIDs. 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 subparagraph 13e).

14. MEL. If RNP 10 operational approval is granted on the basis of a specific operational procedure (such as credit for triple mix), operators should make MEL adjustments specifying the required dispatch/takeoff conditions through their applicable authorization office.

15. Continuing Airworthiness (Maintenance Requirements). The operator will provide document references, if any, for periodic testing, inspection, or maintenance requirements prescribed for LRNSs.

16. Operational Requirements.

a. Navigational Accuracy. All aircraft will meet a trackkeeping accuracy equal to or better than ±10 NM for 95 percent of the flight time in RNP 10 airspace. All aircraft will meet along-track positioning accuracy of ±10 NM for 95 percent of the flight time in RNP 10 airspace.

b. Navigation Continuity. Loss of function is classified as a major failure condition for oceanic and remote navigation. This continuity requirement is satisfied by the carriage of dual, independent LRNSs (excluding Signal in Space (SIS)).

Note: Due to the unique surveillance coverage provided in the Gulf of Mexico, the continuity requirement can be satisfied by carriage of an S-LRNS, provided it complies with subparagraph 13b(5).

c. Navigation Integrity. The navigation system(s) shall have integrity such that the system does not provide misleading information.

d. Flight Plan Annotation.

(1) Operators should make the FAA or ICAO flight plan annotations specified for the area of operations to be flown. The letter "R" should be placed in ICAO Flight Plan item 10 (Equipment) to indicate that the pilot has reviewed the planned route of flight to determine the applicable RNP requirements or options and that the FAA has approved the aircraft and operator.

(2) In addition, certain areas of operation require that ICAO Flight Plan item 10 be annotated with letter "Z" to indicate that item 18 (Other Information) contains additional navigation capability information.

(3) For oceanic operations, item 18 may then be required to be annotated with "NAV/RNP10" or "NAV/RNP4," as appropriate.

Note: The letter that indicates RNP approval has not yet been established for FAA Flight Plans.

e. Availability of NAVAIDs. At dispatch or during flight planning, the operator should ensure that adequate NAVAIDs are available en route to enable the aircraft to navigate to RNP 10.

f. Route Evaluation for RNP 10 Time Limits for Aircraft Equipped with Only INSs or IRUs. As detailed in subparagraph 13e, an RNP 10 time limit must be established for aircraft equipped with only INSs or IRUs to meet the RNP 10 accuracy requirement. When planning operations in areas where RNP 10 is applied, the operator must evaluate its intended route(s) of flight in relation to the RNP 10 time limit. In making this evaluation, the operator must consider the effect of headwinds. The operator may choose to make this evaluation on a one-time basis (75 percent probability wind components) or on a per-flight basis.

(1) Route Evaluation. The operator must establish its capability to satisfy the RNP 10 time limit established for dispatch or departure into RNP 10 airspace.

(2) Start Point for Calculation. The calculation should start at the point where the system is placed in the navigation mode or the point where it is expected to be updated.

(3) Stop Point for Calculation. The stop point may be one of the following:

- The point at which the aircraft will begin to navigate by reference to ICAO standard NAVAIDs (VOR, DME, non-directional radio beacon (NDB)) or comes under radar surveillance from air traffic control (ATC), or
- The point at which the navigation system is expected to be updated.

(4) Sources of Wind Component Data. The headwind component to be considered for the route may be obtained from any source found acceptable to the FAA. Acceptable sources for wind data include:

- National Weather Service (NWS),

- Bracknell,
- Industry sources such as Boeing Winds on World Air Routes, and
- Historical airline data supplied by the operator.

(5) One-Time Calculation Based on 75-Percent 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, it may use the annual 75 percent probability level to calculate the effect of headwinds. This level has been found to be a reasonable estimation of wind components.

(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 it is determined that the flight will exceed the time limit, then the aircraft must fly an alternate route or delay the flight until it can meet the time limit. This evaluation should be considered a flight planning or dispatch task.

17. Discussion of Certification Actions Related to RNP 10.

a. Improved Performance. The operator may elect to certify the aircraft navigation performance 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 AMC for any systems not identified below.

(1) Aircraft Incorporating INS. For aircraft with INS certified under part 121 appendix G, additional certification is only necessary for operators who choose to certify INS accuracy to better than 2-NM-per-hour radial error.

(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.

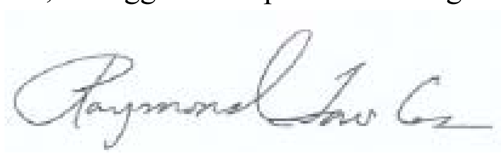
(b) The applicant should identify the standard against which it will demonstrate INS performance. This standard may be a regulatory (e.g., part 121 appendix G), industry, or applicant-unique specification. A statement should be added to the AFM identifying the accuracy standard used for certification. See subparagraph 13a(2).

(2) Aircraft Incorporating GPS. AC 20-138 provides an AMC for aircraft that use GPS, but does not integrate the GPS with other sensors. Aircraft that intend to use GPS as the only navigation system in RNP 10 airspace (e.g., no IRS or INS) must also comply with AC 20-138, appendix 1, and the specific GPS requirements described in this order.

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

c. RNP 10 Oceanic and Remote Airspace. 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.

18. Directive Feedback Information. For your convenience, FAA Form 1320-19, Directive Feedback Information, is the last page of this order; note any deficiencies found, clarifications needed, or suggested improvements regarding the contents of this order on FAA Form 1320-19.

for 

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Appendix A. Aircraft Eligibility Through Data Collection

1. General.

a. Purpose. This appendix offers broad guidance to principal operations inspectors (POI) in the use of a statistical procedure to determine whether aircraft should be approved for flight in RNP 10 airspace.

(1) Inspectors are to consider each application on its own merit and should weigh such factors as:

- The operator's experience,
- The crew training procedures,
- The airspace in which error data is accumulated (e.g., North Pacific (NOPAC), Central East Pacific (CEP), National Airspace System (NAS), minimum navigation performance specification (MNPS)), and
- The age of the data.

(2) Inspectors may request a review of the data by the regional Next Generation (NextGen) Branch (AXX-220) or by the Flight Technologies and Procedures Division (AFS-400). See the RNP 10 job aids for points of contact (POC).

b. Specific Combination of Aircraft and Navigation System. RNP 10 approvals will be issued for specific combinations of aircraft and navigation systems. If the navigation system, which is a candidate for RNP 10 approval, is an inertial navigation system (INS), inertial reference system (IRS), or any other system whose accuracy decreases with increasing flight time, the approval 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.

c. Statistical Tests. This appendix describes statistical tests that use data gathered from repeated flights. Invoking standard statistical terminology, this appendix refers to each such flight as an "independent trial." In each trial, the operator measures two errors:

- The longitudinal position-determination error of the candidate navigation system, and
- The lateral deviation of the candidate aircraft from its planned route centerline.

(1) 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.

(2) 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 is typically gathered after an aircraft has flown for at least as long as the time for which operational approval is being requested, while being guided solely by the navigation system, which is a candidate for RNP 10 approval.

d. Data Collection Requirements. An operator requesting RNP 10 approval for a candidate aircraft and navigation system must inform the FAA 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, may not ignore data that shows large errors while submitting only data that shows small errors.

2. Data Collection Guidelines.

a. Time of Collection. Operators using the methods described in this appendix 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 approval for a stated number of hours *h*, the data must be collected at least *h* hours after that navigation system was last updated or initialized. 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.

b. Position Estimates. In order to determine the lateral and longitudinal error data, the operator must simultaneously obtain position estimates from the navigation system, which is a candidate for RNP 10 approval (the candidate system), and 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.)

(1) 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.

(2) The operator must ensure that the aircraft's 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.

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

- Distance measuring equipment (DME)/DME positions taken within 200 nautical miles (NM) of both DME stations, derived automatically and displayed on systems such as flight management computers (FMC);
- Global Positioning System (GPS)-derived positions; and
- Very high frequency (VHF) omnirange station (VOR)/DME positions taken within 25 NM of the Navigational Aid (NAVAID).

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.

d. Coordinate System. The positions simultaneously reported by the candidate system and the reference system must both be expressed (or reexpressed) in terms of the same coordinate system.

(1) 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. Thus, 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.

(2) 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.

(3) 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.

e. Example. Suppose, for example, that an operator wishes to obtain RNP 10 approval of an airplane equipped with an INS, and that the RNP 10 time limit being sought for the INS is 6 hours. Suppose also that the airplane 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 the last use of another navigation system or signal to adjust its INS output.

(1) On each occasion when—

- The airplane is flying in an area of multiple DME coverage;
- At least 6 hours have passed since the last adjustment of INS output; and
- The airplane has been flying straight for several minutes, and is expected to continue flying straight for several more minutes,

(2) The crew records—

- The time,
- The desired track (or just the "from" and "to" waypoints),
- The position reported by the INS, and
- The position reported by the multiple-DME system.

(3) The operator later computes the longitudinal error a_i and the lateral deviation c_i.

f. Non-Technical Summary. The following is a non-technical summary of the steps used in collecting, plotting, and analyzing 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. This data should be taken when first leaving Class II navigation at the designation end of the flight.

(1) Collect Data. The operator collects the following independent data on each eligible flight:

(a) On the desired flightpath, the last waypoint (last waypoint passed) and the "to" waypoint (these points should be taken from the flight plan).

(b) The reference system (e.g., DME/DME) computed aircraft position.

(c) Aircraft guidance system (e.g., INS) computed aircraft position for each system.

Note: The subparagraph 2f(1)(b) and (c) measurements should be taken simultaneously.

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

(3) Analyze Data. The data gathered in subparagraph 2f(1) is now used to calculate:

(a) The cross-track error (XTK) (lateral deviation c_i).

(b) The track error (longitudinal deviation a_i).

Note: The element a_i in subparagraph 2f(3)(b) is considered to represent along-track error.

(4) XTK (c_i). Calculate the perpendicular distance from the reference-system-computed aircraft position to the desired flightpath. The desired flightpath is a great circle line between the last waypoint and the "to" waypoint.

(5) 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 flightpath.

(6) Cross-Track Pass/Fail.

(a) Following the flights, errors are summed. For example, if the error was 2 NM on the first flight and 3 NM on the second flight, then the cumulative error would equal 5 NM.

(b) 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 A-1, Acceptance, Rejection, and Continuation Regions for Sequential Test of Lateral Conformance.

(c) 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 go above the upper fail line.

(7) Along-Track Pass/Fail.

(a) Following each flight, the errors are squared; following the flights, the errors squared are summed. For example, if the error was 2 NM on the first flight and 3 NM on the second flight, then the cumulative squared errors would be calculated as 4+9=13.

(b) 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 A-2, Acceptance, Rejection, and Continuation Regions for Sequential Test of Longitudinal Accuracy.

(c) 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.

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

h. Standard Documentation Form. The operator should develop a standard form on which to document each flight. It should include:

(1) Date;

(2) Departure airport;

(3) Destination airport;

(4) Aircraft type, series, and registration number;

(5) Make and model of the candidate navigation system;

(6) Type of reference system used (e.g., VOR/DME, DME/DME);

(7) Time at which the candidate system is updated while en route;

(8) Times (if any) at which the candidate system is updated while en route;

(9) Time at which positions are recorded from the candidate system and the reference system;

(10) Reference system position coordinates;

(11) Candidate system position coordinates; and

(12) Desired track or waypoints passed immediately before and after the recorded positions.

i. Compute Lateral Deviation and Longitudinal Error. After the flight, the operator computes the lateral deviation c_i and the longitudinal error a_i, as indicated above.

3. Statistical Procedures.

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

(1) The candidate aircraft and navigation system satisfy the RNP 10 performance requirements, and the statistical test is terminated;

(2) The candidate aircraft and navigation system do not satisfy the RNP 10 performance requirements, and the statistical test is terminated; or

(3) The operator needs to perform another trial (i.e., gather more data) and continue the statistical test, as it cannot yet reach a decision with the required level of confidence.

b. Number of Trials. 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 (i.e., to demonstrate RNP 10 compliance). However, for the FAA 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.

c. 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 A-1 and described in subparagraph 3c(3).

(1) 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.

(a) 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.

(b) 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.

(c) 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 $2.968(n+1)+37.853$.

(2) In other words, let $S_{c,n}=c_1+c_2+...+c_n$ be the sum of (the absolute values of) the lateral deviations obtained in the first n trials.

(a) If $S_{c,n}\leq 2.968n-37.853$, the aircraft and its navigation system pass the lateral conformance test.

(b) If $S_{c,n}\geq 2.968n+37.853$, the aircraft and its navigation system fail the lateral conformance test.

(c) If $2.968n-37.853<S_{c,n}<2.968n+37.853$, the operator must—

- Perform another trial to obtain c_{n+1};
- Compute $S_{c,n+1}=c_1+c_2+...+c_n+c_{n+1}(=S_{c,n}+c_{n+1})$;
- Compare $S_{c,n+1}$ to $2.968(n+1)-37.853$ and to $2.968(n+1)+37.853$; and
- Determine whether the candidate aircraft and navigation system pass the test or fail the test, or whether another trial ($n+2$) is needed.

(3) Figure A-1 illustrates these rules for the lateral conformance test.

(a) The operator may wish to plot points on Figure A-1 as lateral deviation data is collected. The abscissa (horizontal component) of each plotted point is n, the number of trials completed. 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.

(b) 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.

(4) 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: $D_1 = c_1^2 + c_2^2 + \ldots + c_{200}^2$.

(b) Compute the quantity: $D_2 = \frac{S_{c,200}^2}{200} = \frac{(c_1 + c_2 + \ldots + c_{200})^2}{200}$.

(c) Compute the quantity: $D_c^2 = \frac{D_1 - D_2}{200}$.

(d) 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 approval.

d. 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 in subparagraphs 3d(1) and (2), or use the graph provided in Figure A-2, as described in subparagraph 3d(3).

(1) 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.

(a) If the sum of the squares of the longitudinal errors does not exceed 22.018*n*-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.

(b) If the sum of the squares of the longitudinal errors exceeds 22.018*n*+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.

(c) If the sum of the squares of the longitudinal errors is between 22.018*n*-397.667 and 22.018*n*+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.

(2) In other words, let $S_{a,n} = a_1^2 + a_2^2 + \ldots + a_n^2$ be the sum of the squares of the longitudinal errors obtained in the first *n* trials.

(a) If $S_{a,n} \leq 22.018n - 397.667$, the aircraft and its navigation system pass the longitudinal accuracy test.

(b) If $S_{a,n} \geq 22.018n + 397.667$, the aircraft and its navigation system fail the longitudinal accuracy test.

(c) If $22.018n-397.667<S_{a,n}<22.018n+397.667$, the operator must:

- Perform another trial to obtain another longitudinal error a_{n+1};
- Compute $S_{a,n+1}=a_1^2+a_2^2+\ldots+a_n^2+a_{n+1}^2$ $(=S_{a,n}+a_{n+1}^2)$;
- Compare $S_{a,n+1}$ to $22.018(n+1)-397.667$ and to $22.018(n+1)+397.667$; and
- Determine whether the candidate aircraft and navigation system pass the test or fail the test, or whether another trial (n+2) is needed.

(3) Figure A-2 illustrates the rules for the sequential test of longitudinal accuracy.

(a) The operator may wish to plot points on Figure A-2 as longitudinal error data are collected. The abscissa (horizontal component) of a plotted point is n, the number of trials completed. 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.

(b) 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.

(4) 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: $D_3=\dfrac{(a_1+a_2+\ldots+a_{200})^2}{200}$.

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

(c) 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 approval.

Figure A-1. Acceptance, Rejection, and Continuation Regions for Sequential Test of Lateral Conformance

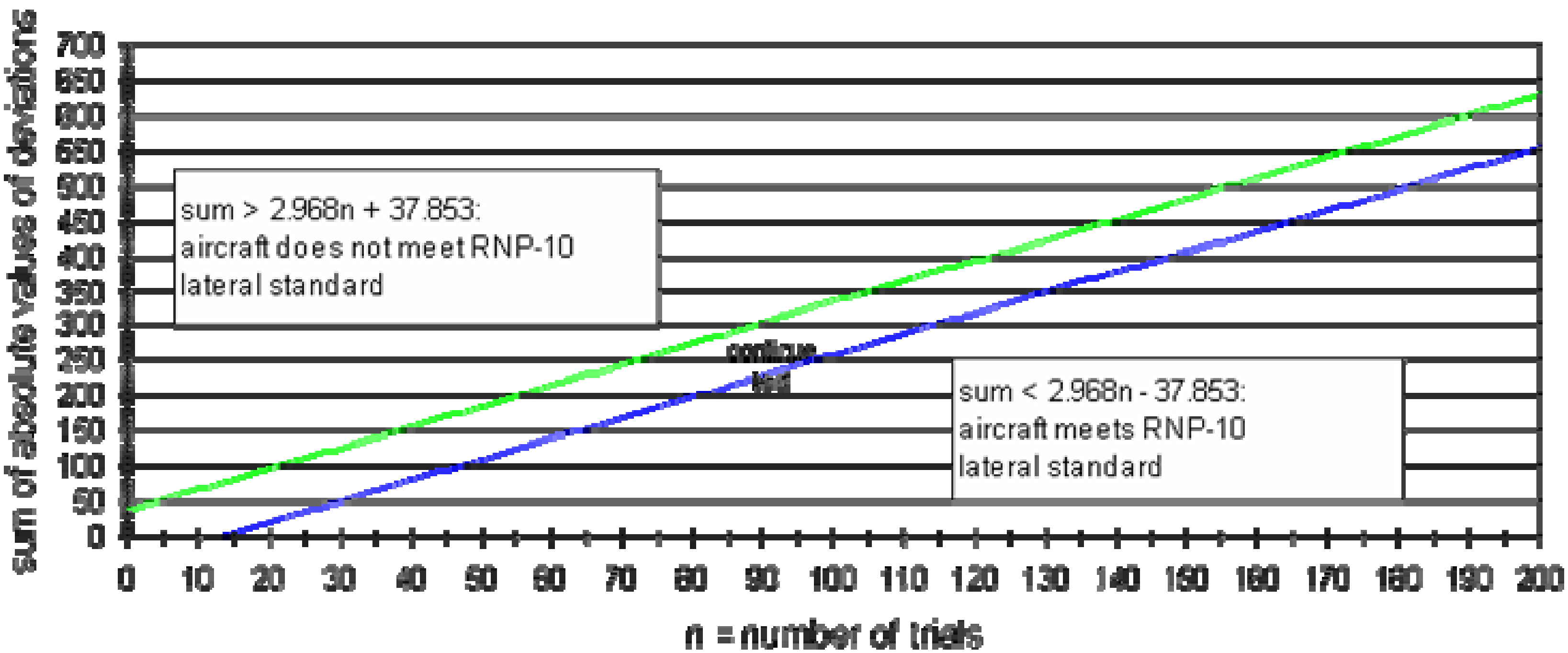
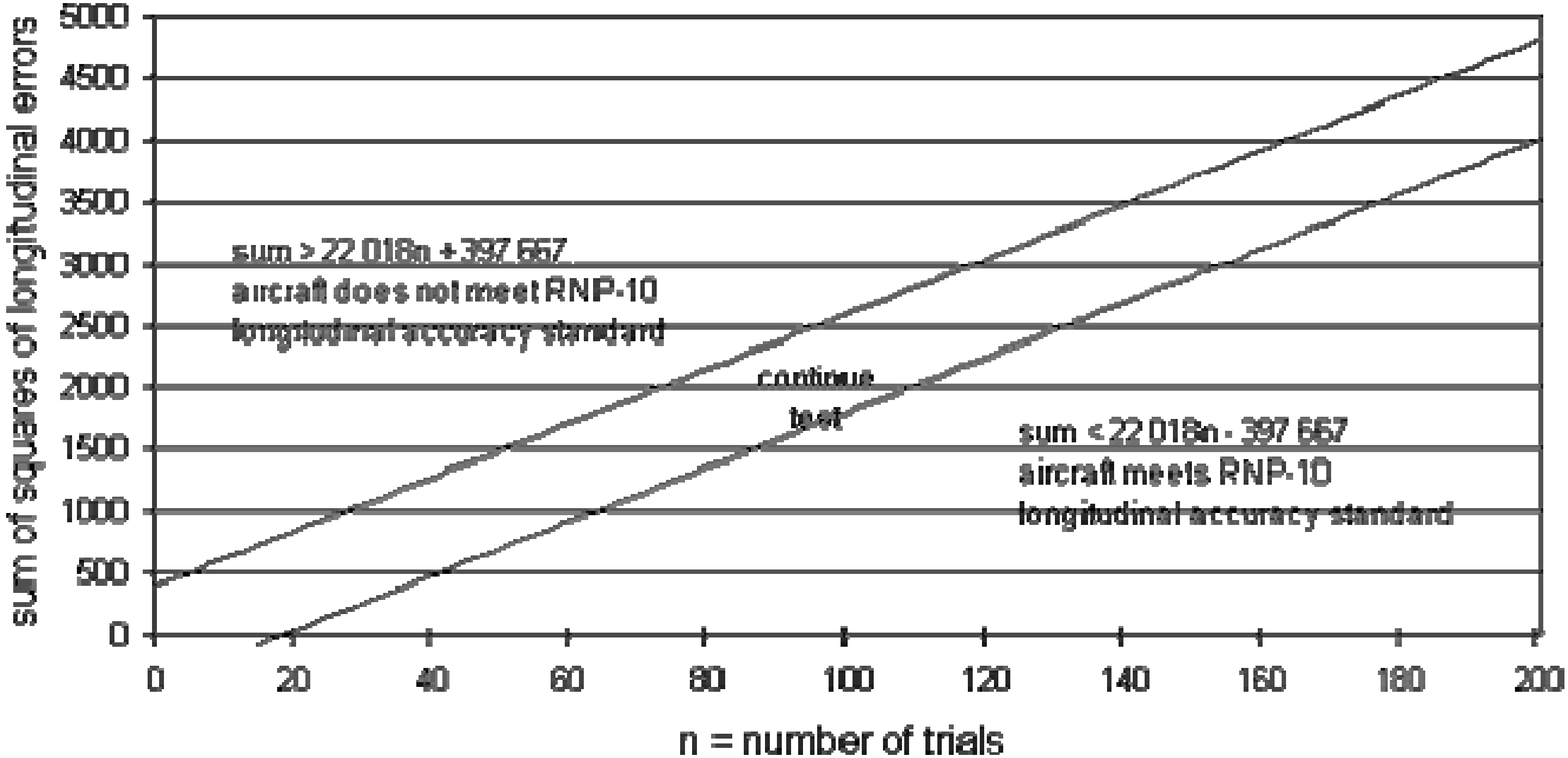


Figure A-2. Acceptance, Rejection, and Continuation Regions for Sequential Test of Longitudinal Accuracy



Appendix B. Certification of Inertial Reference Unit Performance

1. Guidelines and Assumptions. Inertial Reference Units (IRU) that meet the current requirements of 14 CFR 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 required by part 121 appendix G are part of the aircraft certification. However, IRU manufacturers believe that the actual performance of some types of IRUs exceeds the current part 121 appendix G requirements. A methodology for analyzing IRU performance, combined with requirements to update IRU manufacturers' specification control drawings, acceptance test procedures, and airline IRU maintenance/removal criteria is described in the paragraph 2.

2. Certification Guidelines.

a. IRU Accuracy and Reliability. IRU accuracy and reliability must be analyzed in conjunction with the flight management system (FMS) 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 analyzed using the same or equivalent methodology as proposed in this paragraph.

(1) The radial navigation error distribution for IRUs is modeled by a Rayleigh distribution. The 95-percent 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.

(2) 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).

(3) 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 (FTE)). Therefore, the maximum time duration of flight operations in RNP 10 airspace will be evaluated and determined as part of the operational approval.

(4) 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.

b. Performance Superior to the Original Certification. 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 should be revised to account for the new tighter tolerance system error budgets.

(1) 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.

(2) 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 that are compliant to the new performance standard.

c. Aircraft Flight Manual (AFM) or Aircraft Flight Manual Supplement (AFMS). The AFM or AFMS must be modified to reflect the certification of IRUs to tighter accuracy requirements, consistent with the current edition of Advisory Circular (AC) 25-4, Inertial Navigation System (INS), subparagraph 5b(4). The AFM should provide sufficient time-dependent information so that the maximum time in RNP 10 airspace can be assessed as part of the operational approval.

d. Production and Field Acceptance Test Procedures. 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.

e. Operator Maintenance Procedures. Operator maintenance procedures will require updating to ensure appropriate monitoring of IRU performance to the new requirements contained in this order and replacement of IRUs on aircraft that do not meet the navigation performance of this new criterion.

f. Procedures for Flight Operations. Procedures for flight operations should 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.

Appendix C. Sample Operator Letter of Request to Obtain RNP 10 Operational Approval

1. Letter of Request. Figure C-1, Sample Letter of Request, is a sample letter of request for an operator to request operational approval for RNP 10 operations in oceanic/remote areas of operation.

2. Letters of Authorization (LOA). Aviation safety inspectors (ASI) can administratively issue an LOA to any General Aviation (GA) operator that meets the requirements of this order. LOAs should be issued through the Web-based Operations Safety System (WebOPSS).

Figure C-1. Sample Letter of Request

SUBJECT: Request for Required Navigation Performance 10 (RNP 10) Approval

TO: Appropriate principal operations inspector (POI) or ASI

[Operator Name] is applying for Federal Aviation Administration (FAA) operations specifications (OpSpecs), management specifications (MSpecs), or letter of authorization (LOA), as appropriate, to conduct Required Navigation Performance 10 (RNP 10) operations in oceanic/remote areas of operation.

[Operator Name] plans to submit its application package showing its compliance with RNP 10 aircraft eligibility, operational and airworthiness requirements on _______. [Operator Name] plans to start RNP 10 operations on _______.

The following [Operator Name] aircraft will meet the requirements and capabilities as defined/specified in the current edition of FAA Order 8400.12, Required Navigation Performance 10 (RNP 10) Operational Authorization, dated [DATE], for an RNP 10 qualification.

Airplane M/M/S	**RNP 10 TIME LIMIT**	**S-LRNS NAVIGATION EQUIPMENT M/M**	**COMMUNICATIONS EQUIPMENT M/M**
X-XXX-XX	*	List navigation equipment by manufacturer/model	List communications equipment by manufacturer/model

[* See paragraph 13. If aircraft is equipped with Global Positioning System (GPS) approved for primary means of navigation in oceanic operations, incorporated into a multi-sensor system or installed with inertial navigation system (INS) or flight management computer (FMC)/Inertial Reference Unit (IRU), state: “Unlimited.”]

Training of flightcrew members will be accomplished in accordance with applicable FAA regulations and guidance material.

Sincerely,

[typed name and signature]

[title]

Appendix D. Training Programs and Operating Practices and Procedures

1. Introduction. The items detailed in subparagraphs 2–5 of this appendix should be standardized and incorporated into training programs and operating practices and procedures. Certain items may already be adequately standardized in existing operator programs and procedures. New technologies may also eliminate the need for certain crew actions. If this is found to be the case, then the intent of this appendix can be considered to be met.

2. Flight Planning. During flight planning, the flightcrew member should pay particular attention to conditions that may affect operations in RNP 10 airspace (or on RNP 10 routes). These include, but may not be limited to:

a. Approval. Verify that the aircraft is approved for RNP 10 operations.

b. Time Limit. Verify that the RNP 10 time limit has been accounted for (see paragraph 16).

c. Annotated Flight Plan. Verify that the letter "R" is annotated in item 10 (Equipment) of the International Civil Aviation Organization (ICAO) Flight Plan and, if required for the area of operations to be flown, that item 10 is also annotated with the letter "Z" and item 18 with "NAV/RNP 10."

d. Global Positioning System (GPS) Requirements. Verify the requirements for GPS, such as fault detection and exclusion (FDE), if appropriate for the operation.

e. Operating Restrictions. If required for a specific navigation system, account for any operating restriction related to RNP 10 approval.

3. Preflight Procedures at the Aircraft for Each Flight. The following actions should be completed during preflight:

a. Review Maintenance Logs and Forms. Review maintenance logs and forms to ascertain the condition of equipment required for flight in RNP 10 airspace or on an RNP 10 route. Ensure that the maintenance action has been taken to correct defects to required equipment.

b. External Inspection. During the external inspection of aircraft, pay particular attention to the condition of navigation antenna and the condition of the fuselage skin in the vicinity of each of these antennas. This check may be accomplished by a qualified and authorized person other than the pilot (e.g., a flight engineer or maintenance personnel).

c. Contingency Procedures. Contingency procedures for operations in RNP 10 airspace or on RNP 10 routes are no different than normal oceanic emergency procedures with one exception: crews must be able to recognize and advise air traffic control (ATC) when the aircraft is no longer able to navigate to its RNP 10 approval capability.

4. En Route.

a. Two Long-Range Navigation Systems (LRNS) Required (Except Single Long-Range Navigation System (S-LRNS) RNP 10 authorizations are allowed for the Gulf of Mexico). Except for operation in the Gulf of Mexico, at least two LRNSs capable of navigating to the RNP should be operational at the oceanic entry point. If this is not the case, then the pilot should consider an alternate routing, which does not require that equipment, or diverting for repairs.

b. Check Position Before Entering Oceanic Airspace. Before entering oceanic airspace, the aircraft's position should be checked as accurately as possible by using external Navigational Aids (NAVAID). This may require distance measuring equipment (DME)/DME and/or DME/very high frequency (VHF) omnirange station (VOR) checks to determine navigation system errors through displayed and actual positions. If the system is updated, the proper procedures should be followed with the aid of a prepared checklist.

c. Mandatory Cross-Checking Procedures. Operator in-flight operating drills will include mandatory cross-checking procedures to identify navigation errors in sufficient time to prevent aircraft from inadvertent deviation from ATC-cleared routes.

d. Deterioration or Failure of the Navigation Equipment. Crews will 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. Flightcrew Member Knowledge.

a. Commercial Operators. Commercial operators should ensure that crews have been trained in and are knowledgeable of:

- The topics contained in this order,
- The limits of their RNP 10 navigation capabilities,
- The effects of updating, and
- RNP 10 contingency procedures.

b. Title 14 CFR Part 91 Operators. Part 91 operators should show the FAA that pilots are knowledgeable on RNP 10 operations. The intent is for an applicant for RNP 10 authorization to show the FAA that crewmembers are knowledgeable on the material contained in this order. The following are acceptable ways for an operator to show that crews have adequate knowledge of the RNP 10 operating practices and procedures contained in this order:

(1) FAA inspectors can accept training center certificates without further evaluation.

(2) FAA inspectors may elect to evaluate a training course before accepting a training center certificate from a specific center.

(3) FAA inspectors may accept a statement in the operator's application for an RNP 10 LOA that the operator has and will ensure that crews are knowledgeable of RNP 10 operating practices and procedures contained in this order.

(4) FAA inspectors may accept a statement by the operator that he or she has conducted or will conduct an in-house RNP 10 training program.

(5) FAA inspectors may test the operator's flightcrew to ensure adequate knowledge.

c. Title 14 CFR Part 91 Subpart K (Part 91K)/Part 125 Letter of Deviation Authority (LODA) Program Managers/Operators. Part 91K/125 LODA program managers/operators must show the FAA that they are knowledgeable on the material contained in this order and must ensure that flightcrew members are qualified on the system being used in accordance with the program manager's approved training program.

Appendix E. A Sample Data Collection Process (Periodic Method)

1. Introduction.

a. Data Collection Methods. This appendix describes data collection procedures that have been approved by the Flight Technologies and Procedures Division (AFS-400) on the basis of analysis of the data and multiple validation flights. There are two methods in which data may be collected.

(1) One procedure is based on the use of a hand-held Global Positioning System (GPS) as a baseline for the correct position determination. A nonessential flightcrew member takes the GPS readings and the data collection. Only authorized flightcrew members may operate the navigation system. Although no technical specifications are stated for the GPS unit used, it benefits operators to use the best quality unit that is practical. Poorer quality units might malfunction or provide erroneous data that will distort or negate the data collected and make the process excessively expensive.

(2) The second method involves using a single, un-updated gate position as a data point and performing the calculations at the end of this appendix to determine a RNP 10 limit.

b. Triple-Mix and Individual Units. It is possible to evaluate triple-mix units, individual units, or both using this data collection procedure. The data collection forms are designed for this purpose.

c. Gate Position Only Data Page. Operators desiring 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.

a. GPS Updating. Pilots are requested not to update the inertial navigation system (INS) to a GPS position. Doing so would invalidate the data collected.

b. Data Recording. When recording data, all times are coordinated universal time (UTC). Circle latitude and longitude senses (N or S, E or W). Please record any additional information that could be helpful in analyzing recorded data.

c. 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.

d. INS Initialization. (Figure E-1, Data Page 1.)

(1) Record any unusual movement of the airplane during INS initialization before NAVIGATE (NAV) mode selected, such as wind gusts, an airplane service vehicle bumping the airplane, or settling during fueling.

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

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

(4) Was triple-mix selected? Check yes or no.

(5) Check if updating is by radio navigation of position, yes or no.

e. Times. (Figure E-1.)

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

(2) Record "OFF" time.

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

(4) Record "IN" (at the gate) time.

f. Destination Gate Positions. (Figure E-4, Data Page 4, and Figure E-5, Data Page 5.)

(1) Request that pilots not remove INS updates until INS updated/triple-mix positions are recorded at the gate.

(2) Record the destination gate number, published position, the number of GPS satellite vehicles ("SV" on the data pages) in view, GPS Dilution of Precision (DOP) and Estimated Position Error (EPE) values, and GPS position.

(3) Record INS updated/triple-mix positions.

(4) Remove INS updates.

(5) Record INS un-updated positions and INS distances from the gate position.

(6) Record INS data in the maintenance log as usual.

g. Half-Hourly Position Readings. (Figure E-2, Data Page 2, and subsequent.)

(1) Once every 30 minutes after takeoff (Aircraft Communications Addressing and Reporting System (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 air traffic control (ATC) or cabin communications.

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

(3) Record the last and next waypoints' latitude/longitude and name.

(4) Freeze the GPS and INS positions simultaneously.

(5) Record GPS position.

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

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

(8) Release the frozen INS and GPS positions.

h. En Route INS Updates. Use this section only if manual updating is being evaluated.

(1) Record the identifier of the Navigational Aid (NAVAID) over which updating is accomplished and the NAVAID coordinates.

(2) Record the number of GPS satellites in view and the GPS Position Dilution of Precision (PDOP) value.

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

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

(a) Record the INS updated/triple-mix positions and INS un-updated positions.

(b) Record the GPS position.

i. Radio Navigation INS Updates. Use this section only if manual updating is being evaluated (e.g., ground-based radio navigation positions are used for INS updates). Record:

(1) NAVAID identifiers.

(2) Aircraft position derived from ground NAVAIDs (update position).

(3) Time of update.

(4) INS position before update.

(5) GPS position.

Figure E-1. Data Page 1

Flight No.:_________ UTC Departure Date:_________ Departure Airport: _________________

Aircraft Type: _______ Registration No. N ______ Arrival Airport: _______ Captain: _______

INS INITIALIZATION

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):

____
____
____

INS initialization coordinates (published or GPS): N / S
E / W

Triple-mix selected? Yes _________ No __________

TIMES

	Z	OFF
	Z	Time NAV mode selected
hours	minutes	Time in NAV mode before takeoff
	Z	Time entering Class II navigation airspace
	Z	Approximate time leaving Class II navigation airspace
	Z	Time NAV mode selected
hours	minutes	Approximate time in NAV mode before leaving Class II airspace
	Z	IN
	Z	Time NAV mode selected
hours	minutes	Total time in NAV mode

Figure E-2. Data Page 2

Flight No.:_________UTC Departure Date: _________Departure Airport:__________________

Aircraft Type: _______ Registration No. N_______Arrival Airport:________Captain:________

DATA POINT 1		**Z**		**Altitude**
GPS	No. of SV	DOP	EPE	
GPS Position	N/S		E/W	
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	
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	

Figure E-3. Data Page 3

Flight No.:_________UTC Departure Date: _________Departure Airport:__________________

Aircraft Type: _______ Registration No. N_______Arrival Airport:________Captain:________

DATA POINT 3		**Z**		**Altitude**		
GPS	No. of SV	DOP		EPE		
GPS Position	N/S			E/W		
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		
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	

Figure E-4. Data Page 4

Flight No.:_________UTC Departure Date: _________Departure Airport:__________________

Aircraft Type: _______ Registration No. N_______Arrival Airport:________Captain:________

✈✈✈✈✈✈✈✈✈✈✈✈✈✈✈✈✈✈✈✈

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

COMPLETE DESTINATION DATA ON NEXT PAGE

Figure E-5. Data Page 5

Flight No.:__________ UTC Departure Date:___________ Departure Airport: ___________________

Aircraft Type: _________Registration No. N ________ Arrival Airport: _________ Captain: ________

DESTINATION GPS/INS POSITIONS

Please do not remove INS updates until updated/triple-mix positions are recorded at the gate.
Destination Gate No.

PUBLISHED POSITION → N/S E/W

<table>
<tr><td>GPS</td><td colspan="2">No. of SV</td><td colspan="2">DOP</td><td>EPE</td></tr>
<tr><td>GPS Position</td><td colspan="2">N/S</td><td colspan="3">E/W</td></tr>
<tr><td colspan="2">Triple-Mix Position</td><td colspan="3">Un-Updated Positions</td><td>Distance</td></tr>
<tr><td colspan="2"></td><td colspan="3"></td><td></td></tr>
<tr><td colspan="2"></td><td colspan="3"></td><td></td></tr>
<tr><td colspan="2"></td><td colspan="3"></td><td></td></tr>
</table>

- Name of person recording data (Please print): ______________________________
- Position: ____
- Company Location:____
- Telephone No. (Business and Home): ______________________________

3. RNP 10 Data Reduction Techniques for Periodic, In-Flight Method of Data Collection.

a. Data Collection Period. Collect reference data (GPS) and INS/Inertial Reference Unit (IRU) data at least every 30 minutes after reaching initial cruise altitude. Record latitude, longitude, height, and time at the same time for each system.

b. North-South and East-West Error. Determine North-South and East-West error in nautical miles (NM). This is the difference between GPS and INS/IRU position in NM.

c. Position Error. Graph position error (using GPS as reference) vs. time for each flight.

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

e. Radial Position Error. 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. The 95th Percentile Level of Error. This radial error is the data used to determine the 95th percentile level of error. "The 95th-percentile error level of error" is used here to mean that it is 95-percent probable that the error in a given flight will fall below this level or that the level will be below this level in 95 percent of flights if the number of flights is very large.

g. Root Mean Square (RMS) and Geometric Mean (GM). After collecting the data for all flights, calculate the RMS and GM of the radial errors for each elapsed time point. Also determine the ratio of GM/RMS for each elapsed time point. Use the formulas in Table E-1.

Table E-1. Formulas for Calculating RMS and GM

Formulas	Definitions
$RMS = \left(\frac{1}{n} \sum_{i=1}^{i=n} r_i^2 \right)^{\frac{1}{2}}$	r= Radial error at elapsed time point. n= Number of observations of radial error at equally spaced time intervals.
$GM = \left(\prod_{i=1}^{i=n} r_i \right)^{\frac{1}{n}}$	

h. $R_{(P)}$/RMS. Using the P=95 curve from Figure E-6, Most Probable 95th Percentile Level Distribution of Radial Error in a Sample, 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. Radial Error vs. Elapsed Time. Repeat the above procedure for each elapsed time point. Graph $r_{(95)}$ values of radial error (in NM) vs. 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.

4. Periodic Method Example. As an example, Figure E-7, Table of Radial Errors "*r*" (Use for Airborne Data Collection), and Figure E-8, Table of Radial Errors (Use for Gate Position Data), show a six-flight data set (although 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 navigation (the time was an arbitrary selection to illustrate the means of calculation). Data for individual navigational 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 decides to use gate position, only Figure E-8 should be used.

Table E-2. Symbols Used in Examples and Formulas

Symbol	Definition
r	radial error
r^2	square of the radial error
$\prod r$	product of the radial errors
$\sum$	sum
$\sum r^2$	sum of the squares of the radial errors

Figure E-6. Most Probable 95th Percentile Level Distribution of Radial Error in a Sample

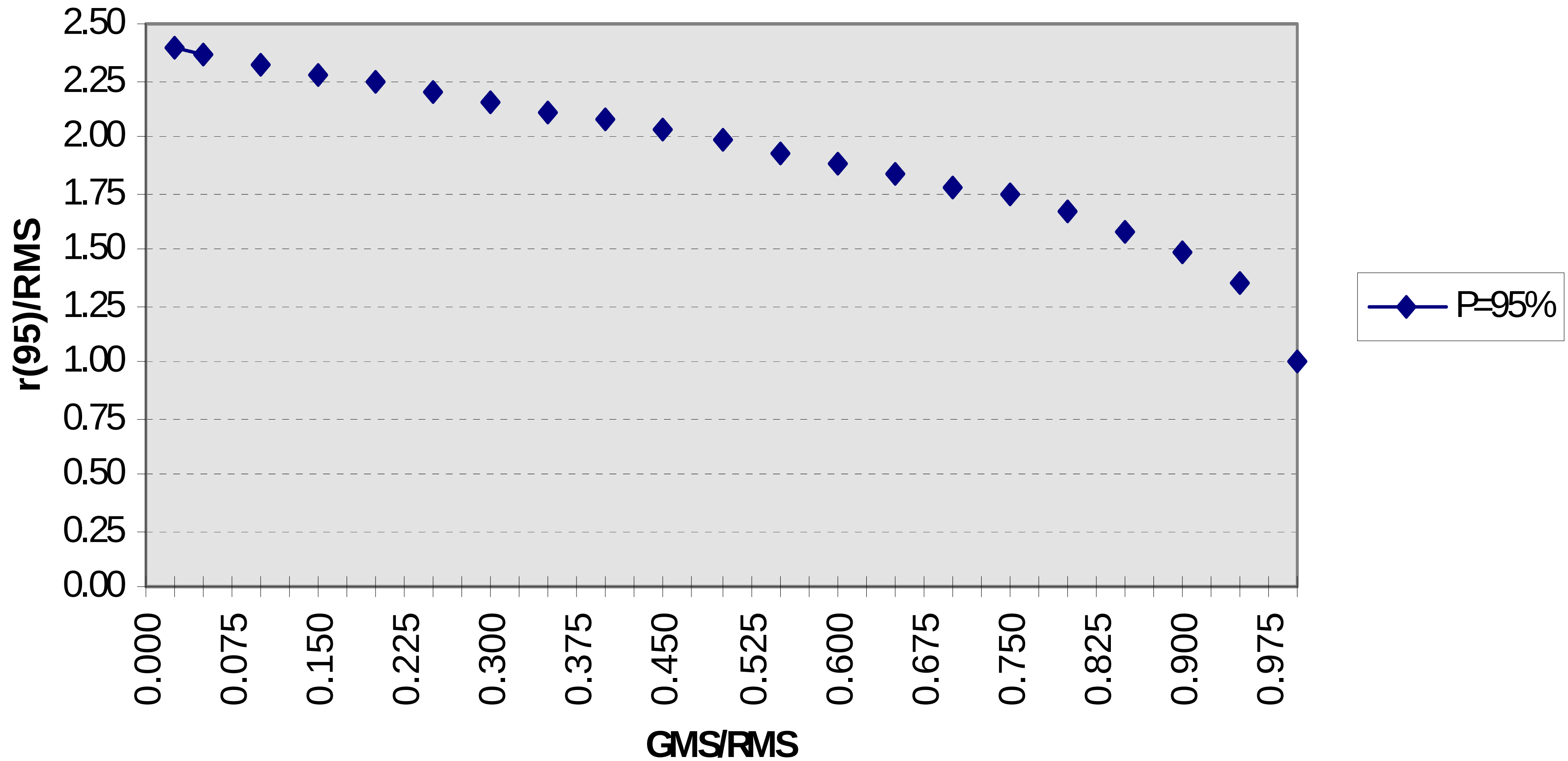


Figure E-7. Table of Radial Errors "r" (Use for Airborne Data Collection)

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 ($\sum r^2$) (column 3) =530.63.

Calculations:

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

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

$$RATIO = \frac{GM}{RMS} = \frac{8.27}{9.40} = 0.88$$

Find this value (0.88) on the abscissa of the "Most Probably Graph" and intersect it with the 95 percent curve to find $r_{(95)}$/RMS (on the ordinate of the graph). Thus, for this example:

$r_{(95)}$/RMS=1.47

The ordinate is defined as $r_{(95)}$/RMS, where $r_{(95)}$=95 percentile of error.

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

$r_{(95)}$= Ordinate value (for the data) x *RMS*=1.47x9.40=13.8 NM

These results indicate:

The 95th percentile level of error at 10 hours is 13.8 NM, which is greater than the required 10 NM; the system would not qualify for RNP 10 for 10 hours based on the data presented.

For guidance on gate position data collection, see Figure E-8, Table of Radial Errors (Use for Gate Position Data).

Figure E-8. Table of Radial Errors (Use for Gate Position Data)

Note: No data is provided for this method. Calculations would be made identical to the procedure used in Figure E-7.

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

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

(1) The product (∏) of radial errors (column 3) = _____________.

(2) The n^{th} route of ∏ = ___________ = GM.

(3) The sum of the radial errors squared ($\sum r^2$)=_____________=*RMS*.

(4) The square root of $\left(\frac{1}{n}\sum r_i^2\right)$=_______________ =*RMS*.

Note: After calculating (2) and (4), use Figure E-6 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 navigation of this flight. Note that this is the data for one flight only; data must be collected in the same manner and in an equal time length for a minimum of 20 flights.

Appendix F. 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.

a. Manual Position Updating. Manual position updating is defined to mean a technique where the crew uses one of the techniques described below to adjust their inertial navigation system (INS) output to compensate for the detected error. The detected error is the difference between the radio navigation position and the INS/Inertial Reference Unit (IRU) position with the radio navigation position being considered the correct position.

b. Means of Manual Updating. Two techniques using very high frequency (VHF) omnirange station (VOR)/distance measuring equipment (DME) or ultrahigh frequency (UHF) Tactical Air Navigational Aid (TACAN) and one technique using a Global Positioning System (GPS) are possible means of manual updating.

(1) 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 flies over a VOR/DME or TACAN facility. The third is similar to the first, but uses a Technical Standard Order (TSO)-C129/C129a/C196 GPS receiver with an approved installation for the update in place of a Navigational Aid (NAVAID).

(2) In each of the three methods, the time that the system was updated should be annotated on the plotting chart or a log that will be retained by the operator for a period of 30 days.

c. Conditions for Updating. The conditions under which any of these methods may be used are as follows:

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

(2) 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 procedure is used as a reference.

(3) The flightcrew member must have a plotting chart in his or her possession.

(4) The GPS or GPS/wide area augmentation system (WAAS) receiver must not indicate an integrity alarm or other fault condition.

2. Training.

a. Commercial Operators. Commercial operators intending to use manual updating procedures must ensure that every flightcrew member using the procedures is trained in the updating procedures. The operator should be able to demonstrate that it has a reliable method of having its crews perform the update, and can be approved by the operator's principal operations inspector (POI) to determine if the method is acceptable. Training manuals must be updated to include the procedures and will be evaluated by the POI as a part of the approval process.

b. General Aviation (GA) Operators. GA operators intending to use manual updating procedures must provide evidence to the responsible office that crews using the procedures are capable of maintaining the same standards as commercial operators.

3. Method 1: Manual Updating Based on Crossing a Fix Along a Route.

a. Timing and Distance. 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 will be at least 50 NM.

b. Updating the Inertial Position. The flightcrew member should tune in the reference VOR/DME or TACAN facility and preselect the appropriate bearing on one course deviation indicator (CDI). As the CDI centers, the flightcrew member will note the distance from the VOR/DME or TACAN facility and mark it on the plotting chart. The flightcrew member will also note the inertial positions of each of the operating INS. The crew will then compare the inertial position against the derived position. The crew then may use the derived position (expressed in latitude/longitude) to update the inertial position. If interpolation is necessary, round up. This procedure would provide a means to restart the RNP 10 clock for an additional, predetermined time.

c. Plotting Chart. To accomplish this manual update, the flightcrew member should have a plotting chart that displays the route fix and DME fixes of 1-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 should be displayed in both DME distance and latitude/longitude coordinates.

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

4. Method 2: Manual Updating when Flying a Route that is Defined by a VOR/DME or TACAN Facility.

a. Accuracy. The accuracy of a manual update when overflying a VOR/DME or TACAN facility is questionable, due to the "cone of confusion" that exists overhead the facility and that 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 should display the bearing and distance and the latitude/longitude coordinates expressed to a tenth of a degree. The specified distances will account for slant range error and radial width.

b. Procedure. In this situation, the suggested procedure would be for the flightcrew member 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 flightcrew member will compare each of the INS positions with the reference latitude/longitude position of the fix. The flightcrew member should attempt the manual update if the along-track position error is greater than 1 NM. After the manual update is completed, the flightcrew member 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. Minimum Requirements. As minimum requirements for use of these procedures, the flightcrew member must have onboard the appropriate plotting charts with the specified information, and the operator must demonstrate that its flightcrews know how to use the charts and procedures.

d. Conditions. 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 air traffic control (ATC) any time it becomes aware that the aircraft can no longer maintain RNP 10 performance based on evaluation of the position checks.

5. Method 3: Using an Instrument Flight Rules (IFR) Approved GPS Installation as an Updating Reference.

a. Overview. Using method 3, the update is performed by comparing the INS position to the GPS position at a chosen waypoint.

b. Updating.

(1) Record the time when INS coordinates are frozen before the en route update is accomplished and the flight level.

(2) Record the number of GPS satellite vehicles locked on and the GPS Dilution of Precision (DOP) and Estimated Position Error (EPE) values.

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

(4) Freeze the GPS and INS positions simultaneously.

(5) From the data, determine the approximate amount of drift per hour flown, make appropriate corrections, and continue to navigate.

(6) If data indicates that RNP 10 capability is impossible to maintain, ATC must be notified as soon as flight conditions will permit.

c. 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 an Oceanic Navigational Error Report (ONER).

(1) 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.

(2) For destination gate positions, do not remove INS updates until updated INS is recorded at the gate.

(3) Record the destination gate number, the number of GPS satellite vehicles in view, and the GPS DOP and EPE values.

(4) Record updated INS position.

(5) Remove INS updates.

(6) Record INS un-updated positions and INS distances from the gate position.

(7) Record GPS position. If GPS position is unavailable, record the gate position (Flight Operations Manual (FOM) airport page 10-7 or airport plan view).

(8) INS data should be recorded in the maintenance log as usual.

(9) Release the frozen INS positions.

U.S. Department
of Transportation
**Federal Aviation
Administration**

Directive Feedback Information

Please submit any written comments or recommendations for improving this directive, or suggest new items or subjects to be added to it. Also, if you find an error, please tell us about it.

Subject: Order 8400.12C, Required Navigation Performance 10 (RNP 10) Operational Authorization

To: Directive Management Officer, ______________________________

(Please check all appropriate line items)

☐ An error (procedural or typographical) has been noted in paragraph _________________ on page ________.

☐ Recommend paragraph _____ on page __________ be changed as follows:
(attach separate sheet if necessary)

☐ In a future change to this directive, please include coverage on the following subject
(briefly describe what you want added):

☐ Other comments:

☐ I would like to discuss the above. Please contact me.

Submitted by: ____ Date: _______________

FTS Telephone Number: ____________________ Routing Symbol: ___________________

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