Advisory Circular

REQUIRED NAVIGATION PERFORMANCE APPROACH (RNP APCH)

1 GENERAL. Advisory Circulars (ACs) are issued by the Civil Aviation Authority of Singapore (CAAS) and contain information about standards, practices and procedures acceptable to the Authority. The revision number of the AC is indicated in parenthesis in the suffix of the AC number.

2 PURPOSE. This advisory circular (AC) provides guidance to the operator applying for operational approval for RNP APCH.

3 APPLICABILITY. This AC applies to all Singapore AOC holders.

4 CANCELLATION. This is the first AC issued on this subject.

5 EFFECTIVE DATE. This AC is effective from 23 July 2010.

6 REFERENCES. The following materials were referred to for the development of this AC:

(a) ICAO PBN Manual Document 9613 AN/937
(b) EASA AMC 20-27

7 INTRODUCTION.

7.1 RNP APCH procedure is an ICAO designator for PBN approach procedures which are non RNP ARs.

7.2 An RNP APCH procedure requires GNSS as primary navigation support for the initial, intermediate and final segments. However, the missed approach segment may be supported by RNAV or conventional navaids such as, VOR, DME, NDB or even navigation dead reckoning.
8 CHARACTERISTICS OF RNP APCH.

8.1 PBN approaches include, but not limited to, such types as RNAV(GNSS), LNAV, LNAV/VNAV and SBAS LPV procedures are types of RNP APCH operations and appended below are some examples:

(a) RNP APCH – LNAV
(b) RNP APCH – LNAV/VNAV (where a vertical guidance system is provided)
(c) RNP APCH – LPV (Localiser Performance with Vertical Guidance)
(d) RNP APCH – LP (SBAS approach where vertical guidance is not available)

8.2 The discussion carried in here is confined to RNP APCH – LNAV operation only and the following are its main characteristics:

(a) Instrument Approach with title of RNAV(GNSS)
(b) Approach path constructed as series of straight segments (T-Y approach)
(c) Descent to an MDA which is published as an LNAV minima
(d) Can be flown with TSO-C129a basic GNSS or RNP 0.3 capable aircraft
(e) Obstacle clearance lateral tolerances not based on RNP value
(f) Vertical flight guidance (e.g. BaroVNAV) may be added

9 AIRCRAFT ELIGIBILITY.

9.1 Airworthiness documents such as AFM, TC, STC, TCDS or manufacturer’s Service Letter attesting to the aircraft system and functional performance capability meeting the standards a set out in FAA AC 20-130A or TSO-C115b are acceptable for evaluation.

9.2 Aircraft with AFM or manufacture’s specific statement of compliance with such documents as EASA AMC 20-26 (RNP AR) and 20-27 (APV BaroVNAV) or FAA AC 90-101 for RNP SAAAR will be accepted without further Airworthiness compliance evaluation.

10 AIRCRAFT SYSTEM PERFORMANCE MONITORING AND ALERTING CRITERIA.

10.1 Accuracy

10.1.1 The lateral and longitudinal TSE (Total System Error) of the onboard navigation system must be equal or better than:

(a) ±1nm for at least 95% of the flight time for the initial, intermediate and RNAV missed approach segments; and
(b) ±0.3nm for at least 95% of the flight time for the final approach segment.

10.1.2 To satisfy the accuracy requirement,

(a) for the initial and intermediate segments and RNAV missed approach of an RNP APCH, the 95% FTE should not exceed 0.5nm;
(b) for the final approach segment of an RNP APCH the 95% FTE should not exceed 0.25nm.
10.2 Integrity

10.2.1 Displaying misleading navigational or positional information to the flight crew during the approach is classified as a major condition under airworthiness regulations and the probability shall be remote (i.e. \(<10^{-5}\) per hour).

10.3 Continuity

10.3.1 Loss of function is classified as a minor failure condition if the operator can revert to a different navigation system and proceed to a suitable airport. Procedures containing conventional missed approach must ensure availability of the necessary air and ground based navigation equipment.

10.4 Performance monitoring and alerting

10.4.1 During initial, intermediate and missed approach segments the RNP system, (or the RNP system and pilot in combination) the aircraft shall provide an alert:

(a) if the accuracy requirement is not met, or

(b) if the probability that the lateral TSE exceeds 2nm is \(>10^{-5}\).

10.4.2 During the final approach segment, the RNP system, (or the RNP system and pilot in combination) aircraft shall provide an alert:

(a) if the accuracy requirement is not met, or

(b) if the probability that the lateral TSE exceeds 0.6nm is \(>10^{-5}\).

10.5 Signal-in-space

10.5.1 The aircraft navigation system shall provide an alert if the probability of signal-in-space errors causing a lateral position error greater than

(a) 2 nm exceeds \(10^{-7}\) per hour for the initial and intermediate segments and for the RNAV missed approach, or

(b) 0.6nm exceeds \(10^{-7}\) per hour for the final approach segment.

Note 1: There are no RNP APCH requirements for a missed approach based on conventional means (VOR, DME, NDB) or on dead reckoning.

Note 2: Compliance with the performance monitoring and alerting requirement does not imply automatic monitoring of a flight technical error. The on-board monitoring and alerting function should consist of at least a navigation system error (NSE) monitoring and alerting algorithm and a lateral deviation display enabling the crew to monitor the flight technical error (FTE). To this extent operational procedures are used to monitor FTE, the crew procedure, equipment characteristics, and installation are evaluated for their effectiveness and equivalence as described in the functional requirements and operating procedures. Path definition error (PDE) is considered negligible due to the quality assurance process and crew procedures

Note 3: The following systems meet the requirements for accuracy, integrity and continuity:

(a) GNSS standalone systems approved in accordance with:

(1) TSO-C129a / ETSO-C129a Class A1 or

(2) ETSO-C146() / TSO-C146() Class Gamma, operational class 1, 2 or 3.

(b) GNSS sensors used in multi-sensor system (e.g. FMS) approved in accordance with:
(1) TSO-C129() / ETSO-C129() Class B1, C1, B3, C3 or

(2) ETSO-C145() / TSO-C145() class 1, 2 or 3.

(c) Multi-sensor systems using GNSS approved in accordance with FAA AC 20-130A or TSO-C115b, having been demonstrated for RNP capability.

Note 4: For GNSS receivers approved in accordance with ETSO-129() / TSO-129() capability for FDE (satellite detection and exclusion) functions are recommended.

11 FUNCTIONAL REQUIREMENTS.

11.1 The table below itemises the required functions for RNP APCH.

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<th>Item</th>
<th>Required Functions</th>
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| 11.1.1 | Navigation data, including a to/from indication, and a failure indication, must be displayed on a lateral deviation display (CDI, (E)HSI) and/or a navigation map display. These must be used as primary flight instruments for the navigation of the aircraft, for manoeuvre anticipation and for failure/status/integrity indication:  
   (a) the displays must be visible to the pilot and located in the primary field of view (±15 degrees from the pilot's normal line of sight) when looking forward along the flight path;  
   (b) the lateral deviation display scaling should agree with any alerting and annunciation limits;  
   (c) the lateral deviation display must also have a full-scale deflection suitable for the current phase of flight and must be based on the TSE requirement. scaling is (1)±1nm for the initial and intermediate segments and (2)±0.3nm for the final segment;  
   (d) the display scaling may be set automatically by default logic or set to a value obtained from a navigation database. The full-scale deflection value must be known or must be available for display to the pilot commensurate with approach values;  
   (e) as an alternate means, a navigation map display must give equivalent functionality to a lateral deviation display with appropriate map scales (scaling may be set manually by the pilot). To be approved, the navigation map display must be shown to meet the TSE requirements;  
   (f) it is highly recommended that the course selector of the deviation display is automatically slaved to the RNAV computed path;  
   Note: This does not apply for installations where an electronic map display contains a graphical display of the flight path and path deviation. |
| 11.1.2 | The capability to continuously display to the pilot flying, on the primary flight instruments for navigation of the aircraft (primary navigation display), the RNAV computed desired path and aircraft position relative to the path.  
   Note: Where the minimum flight crew is two pilots, the means for the pilot monitoring to verify the desired path and the aircraft position relative to the path must also be provided. |
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| 11.1.3 | A navigation database, containing current navigation data officially promulgated for civil aviation,  
(a) which can be updated in accordance with the AIRAC cycle and  
(b) from which approach procedures can be retrieved in their entirety and loaded into the RNAV system. The stored resolution of the data must be sufficient to achieve the required track-keeping accuracy. The database must be protected against pilot modification of the stored data.  
Note: *When a procedure is loaded from the database, the RNAV system is required to fly it as published. This does not preclude the flight crew from having the means to modify a procedure or route already loaded into the RNAV/GNSS system as permitted by paragraph 10. However, the procedure stored in the database must not be modified and must remain intact within the database for future use and reference.* |
| 11.1.4 | The means to display the validity period of the navigation data to the flight crew. |
| 11.1.5 | The means to retrieve and display data stored in the navigation database relating to individual waypoints and navigation aids, to enable the pilot to verify the procedure to be flown. |
| 11.1.6 | Capacity to load from the database into the RNAV system the whole approach to be flown. |
| 11.1.7 | The means to display the either in the pilot’s FOV or on a readily accessible display page on the RNAV CDU, readily visible to the flight crew:  
(a) the identification of the active (To) waypoint;  
(b) the distance and bearing to the active (To) waypoint; and  
(c) the ground speed or time to the active (To) waypoint. |
| 11.1.8 | The means to display the following items on a readily accessible display page:  
(a) the display of distance between flight waypoints;  
(b) the display of distance to go;  
(c) the display of along-track distances; and  
(d) the active navigation sensor type if there is another sensor in addition to the GNSS sensor. |
| 11.1.9 | Capability to execute a “Direct to” function. |
| 11.1.10 | Capability for automatic leg sequencing with display of sequencing to the flight crew. |
| 11.1.11 | Capability to execute database procedures including:  
(a) Fly over and  
(b) Fly by turns |
| 11.1.12 | Capability to automatically execute leg transitions and maintain tracks consistent with the following ARINC 424 path terminators, or their equivalent:  
• ARINC 424 path terminators  
• Initial fix (IF)  
• Track to fix (TF)  
• Direct to fix (DF)  
Note: *Path terminators are defined in ARINC Specification 424, and their application is described in more detail in RTCA DO-236B / EUROCAE ED-75(8) and RTCA DO-201A / EUROCAE ED-77, and EUROCONTROL Document NAV.ET1.ST10.* |
| 11.1.13 | Capability to display an indication of the RNAV system failure, including the associated sensors, in the pilot’s primary field of view. |
| 11.1.14 | Capability to indicate to the flight crew when NSE alert limit in exceeded (alert provided by the “on-board performance monitoring and alerting function”). |
12 OPERATING PROCEDURES.

12.1 Pre-flight planning

12.1.1 The operator must ensure that the flight crew conducting RNP APCH procedures file the appropriate flight plan suffixes and that the on-board navdata are current and include appropriate procedures.

Note: The operator should have a procedure to cope with such in-flight navdata change due to AIRAC cycle.

12.1.2 In addition to the normal pre-flight planning checks, the operator must ensure the following:

(a) the flight crew will use only approach procedure selected from a valid navigation database not prohibited by the operator or NOTAM;
(b) the flight crew are trained and have sufficient means to navigate and land at the destination or at an alternate aerodrome in the case of loss of RNP APCH airborne capability;
(c) the flight crew shall take account of any NOTAMs or operator briefing material that could adversely affect the aircraft system operation, or the availability or suitability of the procedures at the airport of landing, or any alternate airport; and
(d) for missed approach procedures based on conventional means (VOR, NDB), the flight crew shall ensure that the appropriate airborne equipment required for this procedure is installed in the aircraft and is operational and that the associated ground-based nav aids are operational.

12.1.3 The availability of the navaid infrastructure, required for the intended routes, including any non-RNAV contingencies, must be confirmed for the period of intended operations using all available information. Since GNSS integrity (RAIM or SBAS signal) is required by Annex 10, Volume I, the availability of these should also be determined as appropriate. For aircraft navigating with SBAS receivers (all TSO-C145(b) / C146(b)), operators should check appropriate GPS RAIM availability in areas where the SBAS signal is unavailable.

12.2 ABAS availability

12.2.1 RAIM availability prediction should take into account the latest GPS constellation NOTAMs and avionics model (when available). The service may be provided by the ANSP, avionics manufacturer, and other entities, or through an airborne receiver RAIM prediction capability. The operator should ensure that the flight crew are familiar with the RAIM availability prediction information for the intended route.

12.2.2 The operator must provide clear instruction that in the event of a predicted, continuous loss of appropriate level of fault detection of more than five minutes for any part of the RNP APCH operation, the flight planning should be revised (e.g. delaying the departure or planning a different departure procedure).

12.2.3 The operator must be fully aware that RAIM or GPS navigation may altogether be lost while airborne which may require reversion to an alternative means of navigation and must therefore ensure that the flight crew have the capability to navigate (potentially to an alternate destination) in case of failure of GPS navigation.

12.3 Prior to commencing the procedure

12.3.1 The operator shall ensure in the procedure that before the IAF and in compatibility with crew workload, the flight crew shall verify the correct navdata procedure is displayed by comparison with the approach charts and this check must include:

(a) the waypoint sequence; and
(b) reasonableness of the tracks and distances of the approach legs, and the accuracy of the inbound course and length of the final approach segment.
12.3.2 The crew must also check using the published charts, the map display or control display unit (CDU), which waypoints are fly-by and which are flyover.

12.3.3 For multi-sensor systems, the crew must verify, during the approach, that the GNSS sensor is used for position computation.

12.3.4 For an RNP system with ABAS requiring barometric corrected altitude, the current airport barometric altimeter setting should be input at the appropriate time and location, consistent with the performance of the flight operation.

12.3.5 When the operation is predicated on the availability of ABAS, the flight crew should perform a new RAIM availability check if ETA is more than 15 minutes different from the ETA used during the pre-flight planning. This check is also processed automatically 2 NM before the FAF for an E/TSO-C129a Class A1 receiver.

12.3.6 The operator must ensure that the flight crew are fully aware of the limitations of the RNP system with regard to “Direct to” tactical intervention clearance by ATC that:

(a) the manual entry of coordinates into the RNAV system by the flight crew for operation within the terminal area is not permitted; and

(b) “Direct to” clearances may be accepted to the intermediate fix (IF) provided that the resulting track change at the IF does not exceed 45 degrees.

(c) “Direct to” clearance to FAF is not acceptable.

12.3.7 The operator must ensure that the flight crew must never revise the lateral definition of the flight path between the FAF and the missed approach point (MAPt).

12.4 During the procedure

12.4.1 The aircraft must be established on the final approach course no later than the FAF before starting the descent (to ensure terrain and obstacle clearance).

12.4.2 The operator must ensure that the flight crew check the approach mode annunciator (or equivalent) is properly indicating approach mode integrity within 2 NM before the FAF.

Note: This will not apply for certain RNP systems (e.g. aircraft already approved with demonstrated RNP capability). For such systems, other means are available including electronic map displays, flight guidance mode indications, etc., which clearly indicate to the crew that the approach mode is activated.

12.4.3 The flight crew shall select the appropriate displays so that the following information can be monitored:

(a) the RNAV-computed desired path (DTK); and

(b) the aircraft position relative to the path (cross-track deviation) for FTE monitoring.

12.4.4 The procedure must be discontinued:

(a) if the navigation display is flagged invalid; or

(b) in case of loss of integrity alerting function; or

(c) before passing FAF the integrity alerting function is annunciated not available; or

(d) if FTE is excessive.

Note: For multi-sensor system that includes demonstrated RNP capability without GNSS, it may not be necessary to discontinue the procedure. The manufacturer’s documentation should be referred to determine the extent the system may be used in such configuration.
12.4.5 The missed approach must be flown in accordance with the published procedure. Use of the RNAV system during the missed approach is acceptable, provided:

(a) the RNAV system is operational (e.g. no loss of function, no NSE alert, no failure indication); and

(b) the whole procedure (including the missed approach) is loaded from the navigation database.

12.4.6 (a) The operator must ensure that during the RNP APCH procedure, the flight crew use a lateral deviation indicator, flight director and/or autopilot in lateral navigation mode and ensure that lateral deviation indicator (CDI) scaling (full-scale deflection) is suitable for the navigation accuracy associated with the various segments of the procedure i.e.

(1) ±1.0 nm for the initial and intermediate segments,

(2) ±0.3 nm for the final approach segment, and

(3) ±1.0 nm for the missed approach segment.

(b) Unless authorised by ATC to deviate or under emergency conditions, the flight crew must maintain procedure centrelines as depicted by on-board lateral deviation indicators and/or flight guidance during the whole approach procedure.

(c) For normal operations, cross-track error/deviation (the difference between the RNAV system computed path and the aircraft position relative to the path) should be limited to ±½ the navigation accuracy associated with the procedure (i.e. 0.5 nm for the initial and intermediate segments, 0.15 nm for the final approach segment, and 0.5 nm for the missed approach segment). Brief deviations from this standard (e.g. overshoots or undershoots) during and immediately after turns, up to a maximum of one-times the navigation accuracy (i.e. 1.0 nm for the initial and intermediate segments), are allowable.

12.4.7 When BaroVNAV is used for vertical path guidance during the final approach segment, deviations above and below the BaroVNAV path must not exceed +30 m / −15 m (+100 ft / −50 ft), respectively.

12.4.8 Unless positive visual references are acquired to continue the approach, the flight crew must execute a missed approach if the lateral deviations or vertical deviations exceed the above criteria.

12.5 General operating procedures

12.5.1 Unless operational approval to for RNP APCH is obtained from the Authority, the operator shall ensure that the flight crew do not request or engage in RNP APCH operations.

12.5.2 The operator shall ensure the flight crew comply with any instructions or procedures identified by the manufacturer as necessary for safe operation.

12.5.3 Unless specifically approved by the Authority the operator shall ensure that the RNP APCH approach is flown with flight director and autopilot systems.

12.6 Contingency procedures

12.6.1 The operator shall develop contingency procedures to cope with loss of the RNP APCH capability during the approach. This procedure shall require the flight crew to notify the ATC of loss of RNP APCH capability as well as the procedural course of action

12.6.2 The contingency procedure shall contain instruction to the flight crew during communications failure to continue with the RNP APCH in accordance with the published loss of communication procedure.
13 PILOT KNOWLEDGE AND TRAINING.

13.1 The list below describes the scope of training necessary for proficiency of RNP APCH operations. Subject to the Authority’s discretion, operators who are RNAV experienced may submit a truncated version for approval.

(a) the concept of PBN operation and contents of this BaroVNAV Attachment;
(b) the meaning and proper use RNP systems;
(c) ICAO Doc 8168 Vol 1 Chapter 1 Table I-4-1-2 Speeds for procedures calculations.
(d) procedure characteristics, as determined from chart depiction and textual description
(e) knowledge regarding depiction of waypoint types (flyover and fly-by) and path terminators (IF, TF, DF) used by the operator) as well as associated aircraft flight paths;
(f) knowledge on the required navigation equipment in order to conduct RNP APCH operations;
(g) Knowledge of RNP system specific information:
   (1) levels of automation, mode annunciations, changes, alerts, interactions, reversions, and degradation;
   (2) functional integration with other aircraft systems;
   (3) the meaning and appropriateness of route discontinuities as well as related flight crew procedures;
   (4) monitoring procedures for each phase of flight;
   (5) types of navigation sensors utilised by the RNP system and associated system prioritisation/weighting/logic;
   (6) turn anticipation with consideration to speed and altitude effects; and
   (7) interpretation of electronic displays and symbols.
(h) knowledge of RNAV equipment operating procedures including how to perform the following actions:
   (1) verify the currency of the aircraft data;
   (2) verify the successful completion of RNP system self-tests;
   (3) initialise RNP system position;
   (4) retrieve and fly an RNP APCH;
   (5) adhere to speed and/or altitude constraints associated with an approach procedure;
   (6) fly interception of an initial or intermediate segment of an approach following ATC notification;
   (7) verify waypoints and flight plan programming;
   (8) fly direct to a waypoint;
   (9) determine cross-track error/deviation;
   (10) insert and delete route discontinuity;
(11) perform gross navigation error check using conventional navigation aids in accordance with approved procedures; and

(12) change arrival airport and alternate airport;

(i) knowledge of operator-recommended levels of automation for phase of flight and workload, including methods to minimise cross-track error to maintain procedure centreline;

(j) knowledge of radio telephony phraseology for RNP applications; and

(k) ability to conduct contingency procedures following RNP system failures.

14 NAVIGATION DATABASE INTEGRITY.

14.1 The navigation database integrity must comply with RTCA DO-200A / EUROCAE ED-76 standards. The operator must ensure that the navigation database supplier or vendor to the operator hold valid Type LOA (Letter of Approval issued in accordance with FAA AC 90–153 or EASA IR 21(G) / EASA Nr 01/2005.

14.2 The operator should also conduct additional navdata check of any new or changed procedure. Reports on navigation error must be acted upon promptly. Repeated navigation error occurrences attributed to a specific piece of navigation equipment may result in cancellation of the approval for use of that equipment.

15 WITHDRAWAL OF OPERATIONAL APPROVAL.

15.1 An RNP APCH operational approval is conditional upon compliance with the requirements promulgated in this Section and State AIPs.

15.2 Non-compliance, repeated reports of GNE (gross navigation error) or unsatisfactory corrective action may result in the Authority withdrawing the operational approval.