PERFORMANCE-BASED NAVIGATION (PBN) Operations Plan

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FOREWORD

Advances in navigation performance and functionality have enabled changes in airspace design, separation minima, route spacing, airport access, procedure design and air traffic management. These changes will enable the continued evolution of the air navigation system in important ways that will improve overall safety and operational efficiency.

This is the second edition of the NAV CANADA PBN Operations Plan. Since PBN was introduced, many of the initial concepts for improving air traffic management (ATM) have become a reality and are in various stages of implementation. Our Operations Plan for the implementation of PBN in Canadian airspace continues to be developed collaboratively with our customers and stakeholders in recognition of the shared role, responsibility and benefits that PBN represents.

As air navigation modernizes, it must do so sustainably and responsibly; aircraft emissions and community impact must be considered as we continue to work to make this plan reality.

Rob Thurgur
Vice President, Operations

1. BACKGROUND

1.1 The PBN concept is a global initiative by the International Civil Aviation Organization (ICAO). At the 37th ICAO General Assembly, a resolution was adopted urging implementation of the PBN concept. Resolution number A37-11 states:

Whereas a primary objective of ICAO is that of ensuring the safe and efficient performance of the global Air Navigation System;

Whereas the improvement of the performance of the air navigation system on a harmonized, worldwide basis requires the active collaboration of all stakeholders;

Whereas the Eleventh Air Navigation Conference recommended that ICAO, as a matter of urgency, address and progress the issues associated with the introduction of area navigation (RNAV) and required navigation performance (RNP);

Whereas the Eleventh Air Navigation Conference recommended that ICAO develop RNAV procedures supported by global navigation satellite system (GNSS) for fixed wing aircraft, providing high track and velocity-keeping accuracy to maintain separation through curves and enable flexible approach line-ups;

Whereas the Eleventh Air Navigation Conference recommended that ICAO develop RNAV procedures supported by GNSS for both fixed and rotary wing aircraft, enabling lower operating minima in obstacle-rich or otherwise constrained environments;

Whereas Resolution A33-16 requested the Council to develop a programme to encourage States to implement approach procedures with vertical guidance (APV) utilizing such inputs as GNSS or distance measuring equipment (DME)/DME, in accordance with ICAO provisions;

Recognizing that not all airports have the infrastructure to support APV operations and not all aircraft are currently capable of APV;

Recognizing that many States already have the requisite infrastructure and aircraft capable of performing straight-in approaches with lateral guidance (LNAV approaches) based on the RNP specifications and that straight in approaches provide demonstrated and significant safety enhancements over circling approaches;

Recognizing that the Global Aviation Safety Plan has identified Global Safety Initiatives (GSIs) to concentrate on developing a safety strategy for the future that includes the effective use of technology to enhance safety, consistent adoption of industry best practices, alignment of global industry safety strategies and consistent regulatory oversight;

Recognizing that the Global Air Navigation Plan has identified Global Plan Initiatives (GPIs) to concentrate on the incorporation of advanced aircraft navigation capabilities into the air navigation system infrastructure, the optimization of the terminal control area through improved design and management techniques, the optimization of the terminal control area through implementation of RNP and RNAV SIDs and STARs and the optimization of terminal control area to provide for more fuel efficient aircraft operations through FMS-based arrival procedures; and

Recognizing that the continuing development of diverging Navigation Specifications would result in safety and efficiency impacts and penalties to States and industry;

Noting with satisfaction that planning and implementation regional groups (PIRGs) have completed regional PBN implementation plans; and

Recognizing that not all States have developed a PBN implementation plan by the target date of 2009:

The Assembly:

1) *Urges all States to implement RNAV and RNP air traffic services (ATS) routes and approach procedures in accordance with the ICAO PBN concept laid down in the Performance-based Navigation (PBN) Manual (Doc 9613);*

2) *Resolves that:*

    a. *States complete a PBN implementation plan as a matter of urgency to achieve:*

        1) *implementation of RNAV and RNP operations (where required) for enroute and terminal areas according to established timelines and intermediate milestones;*

        2) *implementation of approach procedures with vertical guidance (APV) (Baro-VNAV and/or augmented GNSS), including LNAV only minima, for all instrument runway ends, either as the primary approach or as a back-up for precision approaches by 2016 with intermediate milestones as follows: 30 per cent by 2010, 70 per cent by 2014; and*

        3) *implementation of straight-in LNAV only procedures, as an exception to 2) above, for instrument runways at aerodromes where there is no local altimeter setting available and where there are no aircraft suitably equipped for APV operations with a maximum certificated take-off mass of 5,700 kg or more;*

    b. *ICAO develop a coordinated action plan to assist States in the implementation of PBN and to ensure development and/or maintenance of globally harmonized SARPs, Procedures for Air Navigation Services (PANS) and guidance material including a global harmonized safety assessment methodology to keep pace with operational demands;*

3) *Urges that States include in their PBN implementation plan provisions for implementation of approach procedures with vertical guidance (APV) to all runway end serving aircraft with a maximum certificated take-off mass of 5,700 kg or more, according to established timelines and intermediate milestones;*

4) *Instructs the Council to provide a progress report on PBN implementation to the next ordinary session of the Assembly, as necessary;*

5) *Requests the Planning and Implementation Regional Groups (PIRGs) to include in their work programme the review of status of implementation of PBN by States*

according to the defined implementation plans and report annually to ICAO any deficiencies that may occur; and

6) *Declares that this resolution supersedes Resolution A36-23.*

1.2 The guidance reference document for PBN is ICAO Document 9613 – Performance-based Navigation Manual. Doc 9613 contains Navigation Specifications and the means of supporting these applications, in terms of required performance, equipment functionality and enabling infrastructure. It provides practical guidance for the development of documents related to; standards, regulations, certification, advisories, guidance and operational approvals. Its use avoids the potential for unnecessary proliferation of differing global RNAV and RNP standards.

2. TERMINOLOGY

2.1. RNAV and RNP systems are fundamentally similar. The key difference between them is the requirement for on-board performance monitoring and alerting. A Navigation Specification that includes a requirement for on-board navigation performance monitoring and alerting is referred to as an RNP specification. RNAV specifications do not require on-board performance monitoring and alerting. An area navigation system capable of achieving the alerting performance requirement of an RNP specification is referred to as an RNP System.

2.2. The PBN concept specifies that aircraft area navigation system performance requirements be defined in terms of the accuracy, integrity, continuity and functionality, which are needed for the proposed operations in the context of a particular airspace concept; availability is a function of the navigation signal in space. This represents a shift from sensor-based to performance-based navigation. Performance requirements are identified in Navigation Specifications, which also identify the choice of navigation sensors and equipment that may be used to meet the performance requirements.

3. PBN NAVIGATION SPECIFICATIONS

3.1 ICAO Doc 9613 details the Navigation Specifications currently available. By defining these Navigation Specifications, PBN supports a globally-harmonized transition to area navigation.

3.2 Although PBN specifications are being adopted world-wide, that does not imply that all Navigation Specifications will have a practical application in the Canadian context. Appendix A provides a brief summary of available Navigation Specifications, and identifies those which are planned for use in Canada.

4. NAVIGATION STRATEGY – HIGH LEVEL GOALS

4.1. NAV CANADA's high level PBN goals contribute to the achievement of the company's overarching objectives regarding: maintaining safety, managing customer service charges, introducing Air Navigation Services (ANS) technology, achieving operational efficiencies, and reducing aviation's environmental footprint. NAV CANADA'S PBN high level goals are:

- To achieve a total PBN environment with ICAO Navigation Specification designated values (RNAV and/or RNP) for all operations;
- To facilitate the implementation of the most efficient lateral and vertical trajectories to the maximum extent possible;
- To provide a return on investment for customers having equipped with advanced functionality avionics while continuing to support operations of aircraft with less advanced capabilities, as long as operationally and financially practical; and
- To leverage the availability of a space-based navigation infrastructure to enable modernization of the ground-based infrastructure for all phases of flight.

5. PBN IMPLEMENTATION

5.1 PBN implementation in Canada follows the guidance outlined in Canada's PBN State Plan published by Transport Canada, and leverages NAV CANADA's ATM and customer investments in capabilities with progressive advances in service initiatives. All future area navigation applications will identify the navigation requirements through the use of performance specifications rather than defining equipage of specific navigation sensors. They are applied when justified by safety and/or financial considerations in areas where the appropriate regulatory and local environment exists. To this end, the implementation of PBN uses the most appropriate Navigation Specification, either RNAV or RNP, needed to meet the demands of the airspace.

5.2 PBN implementation is following an ongoing series of qualification upgrades to aircraft, crew, and the ATM environment. Operators falling behind on these upgrades may temporarily be accommodated, but will not fully realize efficiencies and could face delays and/or future airspace restrictions. As customers upgrade their avionics, greater ATM opportunities will be presented with the potential for future four dimensional (4D), gate-to-gate operations. During transitions, there will be periods of mixed mode operations that will be necessary as PBN technologies are deployed to existing operations. NAV CANADA will continue to incrementally build on successful implementations, evolving service delivery as appropriate. NAV CANADA's goal is to move towards a PBN service philosophy of most capable, best served. This philosophy allows for early return on investment in PBN technology by customers, while avoiding being overly punitive to customers who choose to equip later in the transition.

5.3 PBN implementation is linked to ATM and customers' adoption of new technologies, and is subdivided into the following implementation segments in Canada's PBN State Plan:

- 2013-2017
- 2018-2022
- 2023-2027

5.4 This document details NAV CANADA's PBN goals for the 2018-2022 timeframe.

6. 2018-2022 PBN ENROUTE GOALS

6.1 The introduction of PBN has allowed for advances in system design, and satellite-based navigation presents opportunities to maintain or enhance safety while improving efficiency. Maintaining the current network of ground-based NAVAIDs is no longer effective for current-day operations. **A NAVAID Modernization Plan is being developed and implemented, to meet customer operational needs while maintaining an appropriate contingency structure.**

6.2 In the early days of area navigation, track structures were established in the Arctic Control Area (ACA), Northern Control Area (NCA) and Southern Control Area (SCA) to enhance the utilization of airspace. **These track structures will be removed, facilitating the use of customer preferred trajectories where able.**

6.3 A PBN based fixed route structure will ensure customers' compliance with a common aircraft equipage, and training that will result in a high assurance of track conformance. This enables ATM operations optimizing capacity and efficiency through the use of available separation standards. The development of ATS routes will continue only where structured flows are required to ensure airspace capacity can be achieved through either surveillance or non-surveillance aircraft-to-aircraft and aircraft-to-airspace/obstacle separation. In the 2018-2022 timeframe, NAV CANADA will continue to seek opportunities to enhance airspace capacity through the further construction of closely spaced parallel routes offering opportunities for fewer restrictions in climb, descent and overtake scenarios in congested airspace. Elsewhere, the use of user preferred trajectories combined with metering/coordination waypoints will be available. **To realize these benefits where ongoing structure is required, the existing ATS Jet, Victor and Low Frequency (LF) airway structure will be replaced by a PBN structure consisting of Q, T and L routes.** Q routes are high level fixed area navigation routes (Flight Level 180 and above). **During 2018-2022, they will begin to be designated with an ICAO Navigation Specification of RNP 2.** It is anticipated that the RNP 2 Navigation Specification will facilitate a reduction in the separation standard to as low as 8 nautical miles (NM) between routes. T-routes are low level fixed area navigation routes in controlled airspace (below FL180), whereas L-routes are those same fixed low level routes in uncontrolled airspace. **As with Q-routes, T-routes will also be gradually re-designated as RNP 2 routes, to ensure similar separation standards are available in low level airspace. By the end of 2022, the remaining ATS fixed route structure will be predominantly based on PBN.**

6.4 **Most Canadian high level airspace (Flight Level 180 and above) is expected to be identified as requiring RNP 2 as the primary underlying Navigation Specification.** In airspace where RNP 2 is required as the minimum, unless another means of achieving the required on-board performance monitoring and alerting is certified, this will create a de-facto GNSS mandate in these airspaces.

6.5 Unique Canadian airspace designations of Required Navigation Performance Capability (RNPC) and Canadian Minimum Navigation Performance Specifications (CMNPS) predated the PBN concept and already contain some of the types of performance parameters found in the ICAO Navigation Specifications. RNPC and CMNPS designations do not have a direct ICAO Navigation Specification equivalent. **Before the end of 2022, PBN Navigation Specifications will replace both of these.**

6.6 RNAV 10 (RNP 10) currently supports 50 NM aircraft to aircraft longitudinal separations and 50 NM lateral separations between track centrelines. RNP 10 separation standards are in use in portions of the Edmonton FIR where ATS surveillance services are not available in order to facilitate the more efficient transition of aircraft on and off the polar routes and to and from North Atlantic (NAT) airspace.

6.7 **RNP 4 will be investigated for opportunities to increase efficiency in procedural airspaces.** Current track-to-track separations published in ICAO's Procedures for Air Navigation Services – Air Traffic Management (PANS-ATM; Doc 4444) may not provide sufficient opportunities for service improvements and further investigation of using the "airspace to be protected" concept, based on derived protected airspaces for PBN tracks, will be pursued.

6.8 As part of the NAT Region's plan to transition the Minimum Navigation Performance Specifications (MNPS) airspace to operations using a PBN Navigation Specification, as of 2015 only aircraft approved (certified) for RNAV 10 (RNP 10) and/or RNP 4 may be issued an operational authorization to operate in the NAT High Level Airspace (HLA). Pre-2015 MNPS operational approvals based on the MNPS Navigation Specification will remain valid until 2020. As of 2020, all aircraft that regularly operate in the NAT High Level (formally MNPS) Airspace will need to have operational approval based on the RNAV 10 (RNP 10) or RNP 4 Navigation Specification. Based on the premise of system efficiencies and priority handling, non-approved aircraft planning to operate in this airspace will be unlikely to get clearances via their preferred routes or at their optimum altitudes. **The NAT PBN transition provides for feasible contingency options to support the introduction of ATS surveillance separation using space-based ADS-B in the Gander oceanic control area. Further, the transition from RNPC and CMNPS to operations based on PBN Navigation Specifications in Canadian airspace will support interoperability and seamless operations between these airspaces.**

6.9 The introduction of more widely available ATS surveillance capabilities through space-based Automatic Dependent Surveillance-Broadcast (ADS-B) will provide opportunities to use ATS surveillance separation standards in conjunction with PBN to improve efficiencies, particularly in remote and oceanic airspace. Availability of ADS-B OUT avionics to a broad range of customers and their ability to utilize them without undue restriction will determine the pace of future implementation. According to the PBN State Plan, Canada will plan for the

mandatory use of ADS-B in designated airspace between 2018 and 2022. **An Aeronautical Study will be carried out, studying the requirement to mandate the use of ADS-B OUT.**

7. 2018-2022 PBN TERMINAL GOALS

7.1 Area navigation has been in use in terminal areas for many years; with most major terminal airspaces already using area navigation exclusively for their Standard Terminal Arrivals (STARs). Terminal environments will become more dependent on RNP Navigation Specifications in order to take advantage of reduced airspace to be protected and potentially narrower obstacle clearance areas. Based on aircraft containment, these more predictable lateral paths will enable more efficient use of the terminal airspace. **As terminals continue to redesign their arrival and departure routes for regulatory compliance or to improve efficiencies, more PBN Standard Instrument Departures (SIDs) will be introduced, some vector SIDs will remain, and all non-PBN STARs will be withdrawn.**

7.2 The level of accuracy afforded by RNAV 1 and RNP 1 will offer increases in efficiency in terminal areas. **Where infrastructure allows DME/DME/Inertial (D/D/I) navigation, PBN departure procedures, SIDs and STARs will have an RNAV 1 Navigation Specification; otherwise they will be designated with an RNP 1 Navigation Specification.**

7.3 All PBN STARs will continue to be evolved to provide the most efficient application for terminal operations. **This will include the addition of procedure design based separation to support continuous descent operations.**

7.4 Operational requirements will predicate the use of hybrid, RNAV or RNP SIDs. Hybrid SIDs offer a balance between tactical efficiency and PBN structure, thereby making best use of the separation standards available. RNAV or RNP SIDs will be used where guidance off the ground is necessary or beneficial. Where efficiencies can be gained, SIDs will be designed with crossing restrictions to enable procedure design based separation and to support continuous climb operations. **More SIDs will be developed that are procedurally separated from STARs.**

7.5 Time Of Arrival Control (TOAC) is expected to be introduced in terminal environments when it can be used to increase capacity. **The use of 4D arrival management will be investigated and, depending on availability of certified avionics for our customers, implementing 4D trajectories in terminal operations may become a priority.**

8. 2018-2022 PBN APPROACH GOALS

8.1 Instrument procedures using the ICAO RNP APCH Navigation Specification, and identified as RNAV (GNSS), will be widely available. Canada has been subdivided into eight regions, based on common links primarily related to customers' route structures and geography.

Based on operators within each region meeting a minimum equipment baseline, where practical, RNAV(GNSS) procedures will be developed with at least two distinct minima; one lateral-only minimum descent altitude (LNAV) and one lateral and vertical decision altitude (LNAV/VNAV and/or LPV). This implementation will be completed before the end of 2022.

8.2 No new NDB or VOR instrument approach procedures are proposed for design and **the inventory will be adjusted to fit customer requirements,** as a result of the completed GNSS implementation and NAVAID modernization programs.

8.3 **Development of RNP AR APCH procedures will be expanded.** These procedures will be based on operational requirements developed in consultation with customers and are expected to have segments with RNP values ranging from 1.00 to 0.30 NM, although lower lines of minima will be added where operational and financial considerations demonstrate a material benefit. RNP AR APCH procedures can also be designed for airports that otherwise would not have suitable access owing to the obstacle environment, or where sufficient benefits can be realized from the use of the narrower obstacle clearance areas to improve overall efficiency. A list of airports, provided by NAV CANADA's customers', forms the basis of the priority order for design development.

8.4 **RNP APCH and RNP AR APCH will become primary use approaches**, and ILS will be relied upon only when weather is limiting. Many ILS approaches will be amended to include RNAV transitions to final. The use of RF legs to final approach may be developed where operationally beneficial.

8.5 As the demand for air travel continues to grow, so do the demands on the industry to improve technologies and processes to reduce emissions and other environmental impacts. **Aircraft noise and emissions will be considered when designing RNP APCH and RNP AR APCH to ensure the procedures are as environmentally responsible as practical.**

8.6 'Established on RNP AR' is a new concept for parallel approach operations that integrates RNP-AR approaches into busy parallel runways. This concept leverages the accuracy of the approach to allow greater flexibility when managing the final approach segment, leading to significant reduction in track miles for both equipped and non-equipped aircraft. **'Established on RNP AR' will be implemented at major airports with parallel runways.**

9. 2018-2022 ADDITIONAL PBN GOALS

9.1 The advantage in utilizing a designation of A-RNP for a flight operation is the combined performance and functionality of a range of Navigation Specifications encompassing all phases of flight. Where there is potential for operational advantages, **consideration will be given for the use of the A-RNP Navigation Specification.**

10. BEYOND 2022

10.1 Possible developments beyond 2022 could include a definition for the vertical portion of RNP, however building and adopting new avionics into common usage takes time. Changes tabled today will not be seen until well into the future.

10.2 The ‘Established on RNP AR’ concept may be expanded to incorporate other approach types.

10.3 There may be new airspace mandates that require specific Navigation Specification capabilities. These mandates may be in place for volumes of airspace that have pressures owing to traffic density and/or complexity.

10.4 Further development of TOAC may see reductions in the parameters for the time used to control arrivals.

10.5 The use of RNP or A-RNP Navigation Specifications could reduce and/or eliminate departure divergence currently required at airports with parallel runways.

APPENDIX A

Transport Canada has been approving PBN operations through the issuance of Advisory Circulars (ACs) and Special Authorizations. AC guidance is principally drawn from the material available in ICAO Doc 9613, the PBN Manual. Before the end of 2022, it is expected that all of the required Canadian regulatory/advisory documents necessary for equipment certification and operational approvals for all of the Navigation Specifications identified in the ICAO PBN Manual will be available.

Certification and/or operational approval for any one Navigation Specification does not automatically grant approval for any other Navigation Specification. Aircraft approved to a more stringent accuracy requirement may not necessarily meet all of the functional requirements of a Navigation Specification having a less stringent navigation accuracy requirement.

The following offers a summary of available Navigation Specifications outlined in ICAO Doc 9613, and identifies those which are planned for use in Canada.

RNAV 10 (FORMERLY DESIGNATED AND AUTHORIZED AS RNP 10)

Aircraft equipped with at least two independent long range navigation systems; any combinations of INS/IRU or GNSS meet the RNAV 10 requirements. During operations in airspace or on routes designated as RNAV 10 (RNP 10), the lateral total system error must be within ±10 NM for at least 95% of the total flight time. The along-track error must also be within ±10 NM for at least 95% of the total flight time. 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 plus or minus one half of the navigation accuracy associated with the route (i.e. 5 NM). Brief deviations from this standard (e.g., overshoots or undershoots) during and immediately after route turns, up to a maximum of 1 times the navigation accuracy (i.e. 10 NM), are allowable.

Operations in oceanic or remote airspace using procedural-based separation and RNAV 10 (RNP 10) are supported in ICAO Doc 4444 with a 50 NM lateral and 50 NM longitudinal distance-based separation minima.

RNAV 10 (RNP 10) operational requirements are defined in ICAO Doc 9613, Volume II, Part B, Chapter 1. Canadian specific requirements are defined in Transport Canada Advisory Circular AC 700-006.

RNAV 5

RNAV 5 operations are based on the use of RNAV equipment that automatically determines aircraft position in the horizontal plane using inputs from one or a combination of the following types of position sensors, together with the means to establish and follow a desired path:

- VOR/DME

- DME/DME
- INS or IRS
- GNSS

RNAV 5 is an enroute Navigation Specification. In addition to enroute navigation, applications could include initial Standard Arrival Routing (STAR) segments or ending Standard Instrument Departure (SID) segments, where these leg segments are beyond 30 NM from an aerodrome.

Introduction of RNAV 5 in Canadian airspace applications is of low value since current RNPC airspace requirements already require performance that exceeds RNAV 5 when conducting area navigation.

VOR/DME and DME/DME based RNAV 5 have limited opportunities for application in Canadian airspace owing to the required numbers and geometry of ground based aids to provide a robust infrastructure.

RNAV 5 operational requirements are defined in ICAO Doc 9613, Volume II, Part B, Chapter 2. Canadian specific requirements are defined in Transport Canada Advisory Circular AC 700-015.

RNAV 1 AND RNAV 2

RNAV 1 and RNAV 2 operations are based on the use of the same aircraft equipment as required for RNAV 5. There are other additional aircraft functional and navigation aid infrastructure requirements needed to meet the more demanding RNAV 1 and RNAV 2 performance.

The RNAV 1 and RNAV 2 Navigation Specification is applicable to all routes, inside or outside of controlled airspace, SIDs, and STARS. RNAV 1 and RNAV 2 routes are expected to be conducted in a surveillance environment with direct controller pilot communication (DCPC).

In Canada, RNAV 1 is being applied on certain RNAV departure procedures, SIDs and STARs.

RNAV 1 and RNAV 2 operational requirements are defined in ICAO Doc 9613, Volume II, Part B, Chapter 3. Canadian specific requirements are defined in Transport Canada Advisory Circular AC 700-019.

RNP 4

For RNP 4 operations in oceanic or remote airspace, the aircraft must have at least two fully serviceable independent Long Range Navigation Systems (LRNSs) listed in the flight manual; both must be operational at the point of entry into RNP 4 airspace. RNP 4 position integrity bounding can currently only be met using certified GNSS receivers. The GNSS receivers may be part of a stand-alone navigation system or as one of the sensors in a multi-sensor system. Where GNSS is an input as part of a multi-sensor system, the aircraft's position source must use GNSS positions exclusively during RNP 4 operations.

RNP 4 is intended for use in oceanic or remote airspace where a robust ground-based navigation infrastructure is not available. It supports procedural-based separation defined in ICAO Doc 4444, with a 30 NM lateral and 30 NM longitudinal distance-based separation minima. In order to use this 30/30 separation standard RNP 4 must be combined with additional communication capabilities, specifically Automatic Dependent Surveillance – Contract (ADS-C).

RNP 4 operational requirements are defined in ICAO Doc 9613, Volume II, Part C, Chapter 1. Canadian specific requirements are defined in Transport Canada Advisory Circular AC 700-006.

RNP 1

RNP 1 position integrity bounding can currently only be met using certified GNSS receivers. The GNSS receivers may be part of a stand-alone navigation system or as one of the sensors in a multi-sensor system. Where GNSS is an input as part of a multi-sensor system, the aircraft's position source must use GNSS positions exclusively during RNP 1 operations.

During operations in airspace or on routes designated as RNP 1, the lateral total system error must be within ±1 NM for at least 95% of the total flight time. For normal operations, cross-track error/deviation (the difference between the system computed path and the aircraft position relative to the path, i.e. FTE) should be limited to plus or minus one half of the navigation accuracy associated with the procedure (i.e., 0.5 NM for Basic-RNP 1). Brief deviations from this standard (e.g., overshoots or undershoots) during and immediately after turns, up to a maximum of 1 times the navigation accuracy (i.e., 1.0 NM for RNP 1), are allowable.

For RNP 1 routes, pilots must use a lateral deviation indicator, flight director, or autopilot in lateral navigation mode. Pilots of aircraft with a lateral deviation display must ensure that lateral deviation scaling is suitable for the navigation accuracy associated with the route/procedure (e.g., full-scale deflection: ± 1 NM for RNP 1).

Use of the RNP 1 Navigation Specification enables the use of radius-to-fix (RF) leg segments in applications such as the STAR, transition to the approach or approach initial segments.

RNP 1 operational requirements are defined in ICAO Doc 9613, Volume II, Part C, Chapter 3. Canadian specific requirements are defined in Transport Canada Advisory Circular AC 700-025.

RNP 2

RNP 2 is intended for enroute applications, primarily in areas where there is limited NAVAID infrastructure, ATS surveillance, and low to medium density traffic. Use of RNP 2 (continental) applications requires a lower continuity requirement than the use of RNP 2 (oceanic/remote) applications. RNP 2 also requires the use of certified GNSS receivers.

ICAO sanctioned RNP 2 separation standards are currently being developed; however, that does not preclude the use of RNP 2 for designation on an ATS route or within an airspace volume.

RNP 2 operational requirements are defined in ICAO Doc 9613, Volume II, Part C, Chapter 2. Canadian specific requirements are defined in Transport Canada Advisory Circular AC 700-038.

RNP 0.3

RNP 0.3 was proposed in response to the helicopter community's desire for narrower IFR obstacle free areas, to allow operations in obstacle rich environments and to allow simultaneous non-interfering operations in dense terminal airspace. RNP 0.3 requires the use of certified GNSS receivers.

RNP 0.3 operational requirements are defined in ICAO Doc 9613, Volume II, Part C, Chapter 7, but have not yet been defined in a Transport Canada Advisory Circular; therefore, there is also no currently available associated Special Authorization.

ADVANCED RNP

Advanced RNP (A-RNP) is the only Navigation Specification that enables operations under other associated Navigation Specifications. The aircraft navigation accuracy and functional requirements of other Navigation Specifications that are met when A-RNP is certified are:

- RNAV 5
- RNAV 1
- RNAV 2
- RNP 2
- RNP 1
- RNP APCH

RF is an additional required functional element in A-RNP. The following additional functional elements are optional:

- RNP Scalability
- Higher continuity
- Fixed Radius Transition (FRT)
- Time of Arrival Control (TOAC)
- Baro-VNAV

A-RNP has a very broad operational application; for operation in oceanic/remote airspace, on the continental enroute structure as well as on arrival and departure routes and approaches. Operations would rely solely on the integrity of the RNP system without a reversionary capability to conventional means of navigation since a conventional infrastructure may not be available.

Carriage of a single RNP system is considered generally acceptable; however, where more stringent requirements exist (e.g. dual RNP system to meet a defined continuity performance), these requirements will be defined in the AIP and/or in a regional supplement (ICAO Doc 7030). The implementation of a particular operation would be established through safety cases.

The advantage in utilizing a designation of A-RNP for a flight operation is the combined performance and functionality of a range of Navigation Specifications encompassing all phases of flight. A-RNP operational requirements are defined in ICAO Doc 9613, Volume II, Part C, Chapter 4; however, A-RNP operational requirements in Canada have not yet been defined in a Transport Canada Advisory Circular; therefore, there is also no currently available associated Special Authorization.

RNP APCH

The RNP APCH Navigation Specification position integrity bounding can currently only be met using certified GNSS receivers. The GNSS receivers may be part of a stand-alone navigation system or as one of the sensors in a multi-sensor system. Where GNSS is an input as part of a multi-sensor system, the aircraft's position source must use GNSS positions exclusively during RNP APCH operations.

RNP APCH is the ICAO Navigation Specification designation for approach procedures currently published in Canada using the chart title "RNAV (GNSS)", with minima designated as "LNAV", "LNAV/VNAV", "LP" and "LPV".

RNP APCH operational requirements are defined in ICAO Doc 9613, Volume II, Part C, Chapter 5. Canadian specific requirements are published in Transport Canada Advisory Circular AC 700-023.

RNP AR APCH

RNP AR (Authorization Required) APCH procedures can be designed with various levels of RNP lateral containment values on the Initial, Intermediate, Final and Missed approach segments. There are increasingly demanding aircraft certifications and operational approvals required when RNP values lower than 0.30 NM are applied in any of these segments.

RNP AR APCH procedures are published in Canada using the chart title "RNAV (RNP)". As with all other RNP Navigation Specifications, position integrity bounding for RNP AR APCH can currently only be met using certified GNSS receivers. There are numerous other aircraft equipment and functional requirements needed to meet the demanding performance requirements of RNP AR APCH defined in ICAO Doc 9613, Volume II, Part C, Chapter 6. The Canadian specific requirements are published in the RNP AR APCH Transport Canada Advisory Circular AC 700-024.

RADIUS TO FIX (RF) PATH TERMINATOR

RF path terminators will be used where there is a benefit to having the more predictable, tighter containment over the use of a fly-by or fly-over waypoint leg transition on an RNP route segment. RF path terminators cannot be used in conjunction with an RNAV Navigation Specification.

The RF path terminator operational requirements are defined in ICAO Doc 9613, Volume II, Part C, Appendix 1. The Canadian specific requirements are published in Transport Canada Advisory Circular AC 700-027.

The RF path terminator may be found in instrument procedures based on RNP performance; therefore, AC 700-027 is applicable for use in conjunction with any of the RNP Navigation Specifications.

FIXED RADIUS TRANSITION (FRT)

FRT will be used to define transitions along RNP airways of less than 90 degrees where the separation between parallel routes cannot be achieved with fly-by transitions.

The FRT operational requirements are defined in ICAO Doc 9613, Volume II, Part C, Appendix 2. The operational requirements in Canada have not yet been defined by Transport Canada Advisory Circular and there is no associated Special Authorization.

TIME OF ARRIVAL CONTROL (TOAC)

The Fourth Edition of ICAO Doc 9613, Volume II, Part C, Appendix 3, indicates that Time Of Arrival Control (TOAC) is “to be developed”.

Although it does not exist today, 4D navigation is a priority and NAV CANADA will continue to assist with the evolution of this Navigation Specification at ICAO.