REQUIRED NAVIGATION PERFORMANCE (RNP)

The worldwide Air Traffic Control (ATC) structure is under increased strain because old equipment, in many countries, is inefficient and lacks the capacity to handle the anticipated demand over the next 20 years. The current growth reflects the international need to increase airspace capacity along with airspace user requests to reduce flight time and save money. Our own National Airspace System is not excluded from this challenge.

In response to the growing demands, International Civil Aviation Organization (ICAO) has specified that Required Navigation Performance (RNP) is an essential element of communications navigation surveillance/air traffic management (CNS/ATM) and is encouraging early implementation in the enroute environment. Currently, many States are preparing for the introduction of RNP on air traffic services (ATS) routes in preparation for the implementation of the global CNS/ATM system.

Background: Changing RNPC to RNP

Initially, the special committee on future air navigation (FANS) developed the concept of Required Navigation Performance Capability (RNPC) as "a parameter describing lateral deviations from assigned or selected track as well as along track position fixing accuracy on the basis of an appropriate containment level." (ICAO Doc 9613-AN/397). ICAO approved the RNPC concept and assigned it to the Review of the General Concept of Separation Panel (RGCSP) for further work.

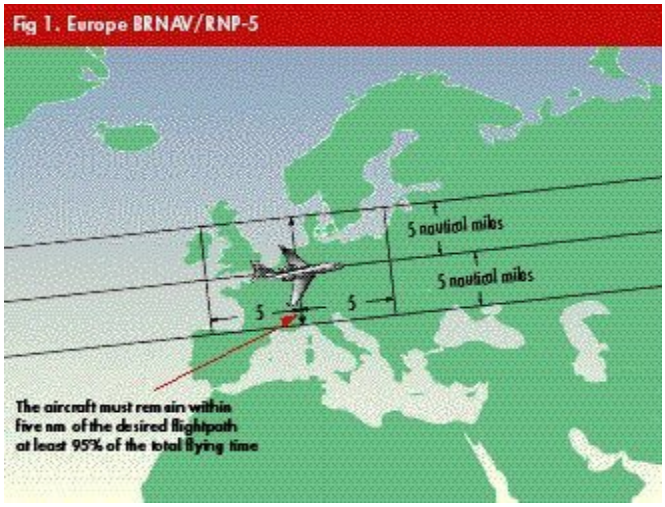
With evolving navigation systems, the RGCSP, in 1990, realized that capability and performance were distinctly different. Since airspace planning is dependent on measured performance rather than designed capability, RNPC was changed to Required Navigation Performance (RNP).

The RGCSP then developed the concept of RNP further by expanding it as a statement of the navigation performance accuracy necessary for operations within a defined airspace or route.

Nav Performance Accuracy: Elements of RNP Containment

The term "navigation performance accuracy" (RNP type) is based on the total system error (TSE) allowed in the horizontal dimension--lateral and longitudinal (crosstrack and along-track). For the lateral dimension, the TSE is assumed to be the difference between the true position of the aircraft and the centerline of the route of flight programmed in the NAV system. The TSE is a combination of the NAV system error, RNAV computation error, display system error and the flight technical error (FTE). In the longitudinal dimension, the TSE is assumed to be the difference between the displayed distance to a specified waypoint and the true distance to that point. The TSE in each of these dimensions must be evaluated independently.

A single accuracy value expresses RNP types in nautical miles. For example, for RNP-10, the TSE is not to exceed 10 nm for 95% of the flight time on any portion of any single flight. RNP can apply from takeoff to landing with each phase of flight requiring a different RNP type.



Navigation systems: RNAV and RNP

Area navigation (RNAV) is the primary means of meeting RNP requirements. RNAV operations within the RNP concept permit flight in any airspace within prescribed accuracy tolerances, without the need to fly directly over ground-based navigation facilities.

Any type of navigation system can be used to provide RNP, provided that it meets the required navigation performance accuracy. RNAV equipment operates by automatically determining the aircraft position by using inputs from one, or a combination, of sources such as VOR, DME, Loran-C, INS and GPS. The primary means for achieving RNP is by the use of RNAV equipment.

Currently, a large percentage of aircraft are configured with a mix of the above equipment leading to varying degrees of performance and RNP-type approvals. For example, in European BRNAV/ RNP-5 airspace (Fig 1), limitations based on the requirement of groundbased navaids may not be an issue for an INS/IRS equipped aircraft to gain approval. However that same aircraft would not be approved to operate on the westbound pacific organized track system (PACOTS), which is designated as RNP-10.

At first glance, RNP-4 approval appears more restrictive. Does that mean if you are approved to operate in RNP-4 airspace, you are automatically approved to operate in RNP-10 airspace? Not necessarily. An INS-equipped aircraft approved for RNP-4 operation with a time restriction of two hours between updates would not be able to operate in the North Pacific Region (NOPAC) designated as RNP-10 without updates. RNP and RNAV operators have the responsibility to ensure that their equipment meets the required "navigation performance accuracy" and that the flightcrews will follow prescribed procedures for the respective RNP type environment.

Table 1. Lateral separation for RNP types

RNP type	Spacing	Basis for spacing requirements
20	100 nm	Existing usage - long standing operational experience
12.6	60 nm	Collision risk model for North Atlantic route system
10	50 nm	Collision risk model for North Pacific route system
5/4	16.5 unidirectional 18 bidirectional	Comparison to VOR reference system (in accordance with ICAO annex 11, attachment A)

Table 2. Longitudinal distance-based separation for RNP types

RNP type	Separation minima	Basis for separation minima
20	80 nm	Safety assesssments for specific network of track or routes
10	50 nm	

ATS Procedures

Future ATS procedures will generally be the same as existing ATS procedures. But special functional requirements may be different for different RNP types. One example is the capability to fly offset from the planned route centerline by a specified distance.

Table 1 and Table 2 illustrate proposed separation minima for RNP and RNAV. Further reductions are under development by ICAO including 30 nm lateral and distance-based longitudinal separation using RNAV and RNP-4. Aircraft and ATC will have to be equipped with automatic dependent surveillance (ADS) and controller-pilot datalink communications (CPDLC).

RNP-Types

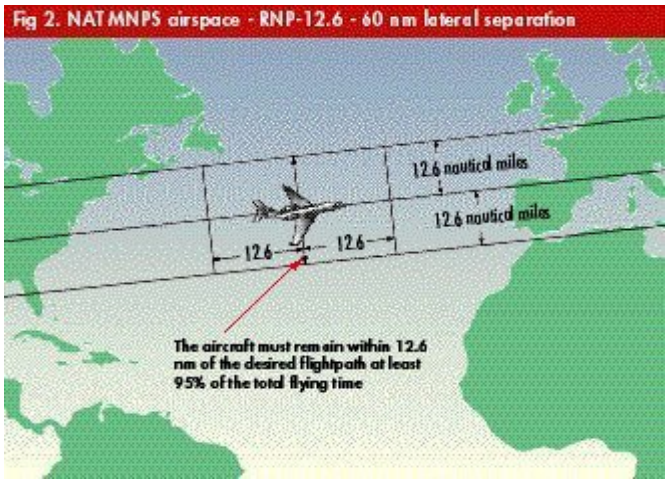
RNP-20 was an early minimum capability considered acceptable to support ATS route operations. But it may not be needed any longer because today's systems already support 100 nm separation.

RNP-12.6 supports optimized routing in areas with a reduced level of navigation facilities such as operations in minimum navigation performance specification (MNPS) airspace in the North Atlantic (Fig 2). NAV equipment for unrestricted operations in MNPS Airspace is listed in the *North Atlantic MNPS Airspace Operations Manual and AC 91-70*. FAA approval is given in the form of a "letter of authorization" (LOA) for Part 91 operators and as part of the operation specifications for Part 135.

RNP-10 supports reduced lateral and longitudinal separation minima and enhanced operational efficiency in oceanic and remote areas where the availability of navaids is limited. On April 23, 1998 Anchorage Air Route Traffic Control Center (ARTCC) implemented lateral separation standards within the NOPAC (North Pacific) route structure from FL 310 to FL 390. On the same day, Australia and New Zealand implemented RNP in the Tasman Sea airspace. (*www.airservices.gov.an /industry/rnp/rnp.htm*) Requirements for aircraft operating in RNP-10 airspace or on RNP routes include the navigation capability to maintain crosstrack as well as along-track error of less than 10 nm 95% of the time. (Fig 3).

As of Dec. 3, 1998 (Oakland NOTAM A4335/98), a 50 nm lateral separation standard was applied in the Central Pacific (CENPAC) (PACOTS only) to all aircraft that are RNP-10 approved. RNP approval is required from FL 310 through FL 390 inclusive for all PACOTS except Tracks A, B, 11, 12, W, X, 20 and 21. The International Airline Pilots Association (IALPA) took a position against the implementation westbound because Oakland ARTCCA can regenerate tracks frequently if there is severe weather but Tokyo ACC can only regenerate the tracks eastbound once every 24 hrs. A monitoring group was formed to collect, coordinate, and review data to reach an agreement on when to expand 50 nm spacing to additional PACOTS tracks.

Issues for the 50 lateral RNP-10 expansion include the RNP-10 eligibility of INS and IRS equipped aircraft for new PACOTS routes and emphasis on weather deviation procedures. Weather deviation procedures in the Pacific Region should be reviewed by all international flightcrews. The intent of these procedures is to minimize the potential for aircraft to conflict during weather deviations from their cleared track and are also intended to clarify the roles and responsibilities of pilots and controllers. The US has published these procedures in the *Flight Information Publication (FLIP) Pacific and Alaska Chart Supplements*. They can also be found in the Jeppesen Enroute P-27 and on Pacific Ocean H/L and High Altitude Charts.



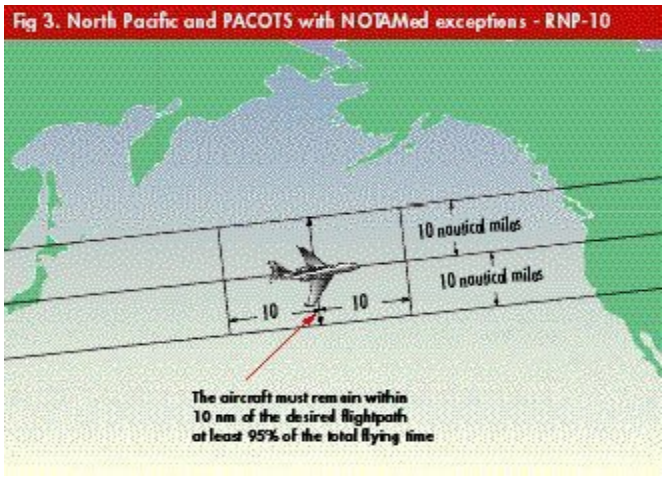
As a reminder, there is a chart NOTAM (26 Mar 99) stating that RNP implementation within the Hawaii composite route system has been delayed until further notice. The information on the Jeppesen Pacific Ocean Altitude Enroute Charts H/L-4/cover panel note #5 (10 Apr 98), stating that RNP approval is required, is incorrect.

Flightcrews should review the planned route of flight to determine RNP requirements and that the aircraft *and* the operator are approved to operate in RNP-10 areas or routes. This is indicated by placing the letter "R" in Item 10 of the ICAO flightplan.

Non-RNP approved aircraft may file a random track, at any altitude, at least 100 nm from any PACOTS track, or the NOPAC. After entering the NOPAC, flightcrews should flightplan in accordance with the Anchorage NOTAM A0004/98. Aircraft and/or crew who do not meet the requirements for RNP-10 operations can expect route and/or altitude restrictions.

The State of Registry or State of the Operator is the authority responsible for approval for flight operations in the various RNP type airspace and routes. RNP approval is issued for the individual aircraft type group/equipment along with individual operational approval. FAA Order 8400.12A should be referenced for guidance on RNP-10 approval as well as the RNP-10 Approval Outline and related NOTAMs--all of which can be found at on the FAA website (*www.faa.gov/ats/ato/rnp.htm*). Authorization is given in the form of an LOA for Title 14 CFR Part 91 and as part of the operations specifications for Part 135.

If you qualify as a Group I, the process seems much simpler than the RVSM approval process. We referenced *The Aircraft Flight Manual* (AFM) and completed the LOA along with assuring our local FSDOs that the flightcrews were "knowledgeable" on the material contained in FAA Order 8400.12A (Appendix 4-5). Although there are no legal requirements for GA operators to have specific training for RNP-10 operations, ICAO does demand that States ensure that flightcrews are qualified to operate in special airspace.



Practices and procedures for flight planning, preflight, enroute and postflight should be incorporated into your international operations manual and training programs. More specifically, know your aircraft's time limitations (if any), verify the requirements for GPS, such as FDE, if appropriate, review the maintenance logs and pay close attention to the NAV antenna during preflight. Enroute, an accuracy check using external NAVAIDs to determine NAV system errors prior to entering oceanic airspace and crosschecking to identify NAV system errors are also required. Flightcrews shall advise ATC of any deterioration or failure of NAV equipment. Operators should also adopt (and document) appropriate RNP maintenance practices and procedures.

As always, detailed inflight recordkeeping is encouraged. A form similar to Fig. 4 can be used to check your FMSs. Flight departments will usually select a time other than the waypoint crossing, such as the 10-min check, to record this type information.

BRNAV/RNP-5 (basic area navigation) approval in European Class Airspace became required for all aircraft and flightcrews operating under IFR on the ATS route network in the European Civil Aviation Conference (ECAC) area including designated SIDS and STARS on Jan. 29, 1998. BRNAV/ RNP-5 allows for the implementation of RNP procedures so as to use the present navigation equipment without changing the route structure. This is intended to enable greater flexibility in airspace design and potential user advantages such as more direct routing and fuel savings. RNP-5 can be achieved by conventional navigation techniques on routes defined as VOR/DME.

An LOA is not required if eligibility is based on the AFM. In order to receive BRNAV/RNP-5 approval, onboard navigation equipment is required to provide enroute lateral navigation accuracy and along track position fixing +/- 5 NM or better for 95% of the flight time. This navigation performance standard assumes that the necessary coverage provided by satellite or ground based navigation aids is available for the intended route to be flown. As with all other RNP designated airspace, the letter "R" must be included in Item 10 of the ICAO Flight Plan.

If you are not B-RNAV/RNP-5 approved (or temporarily become non-approved), you will require special handling by ATC and Item 18 of the ICAO Flight Plan should contain "STS/NONRNAV". The phrase "Unable RNAV due equipment" should be used immediately after initial contact with ATC. Guidance for approval as well as acceptable types of RNAV equipment including "GPS as Primary Means" for B-RNAV can be found in AC No. 90-96 (*www.faa.gov/ats/ ato/rnp.htm.*)

RNP-4 is normally associated with domestic airspace. This type supports ATS routes and airspace design based on limited distance between NAVAIDs. RNP-4 provides for accuracy similar to that of an aircraft navigating on a VOR-defined ATS route where the VORs are spaced at 50 NM or less.

Fig 4. Long Range Navigation System (LRNS) Performance Log

Flightplan position	FMS 1 position	FMS 2 position	Lasref 1 miles from FMS drift rate	Lasref 2 miles from FMS drift rate	Lasref 3 miles from FMS drift rate	GPS Miles from FMS position	GPS FOM-HDOP	GPS Miles from FMS position	GPS status FOM-HDOP

Caribbean "T" Routes

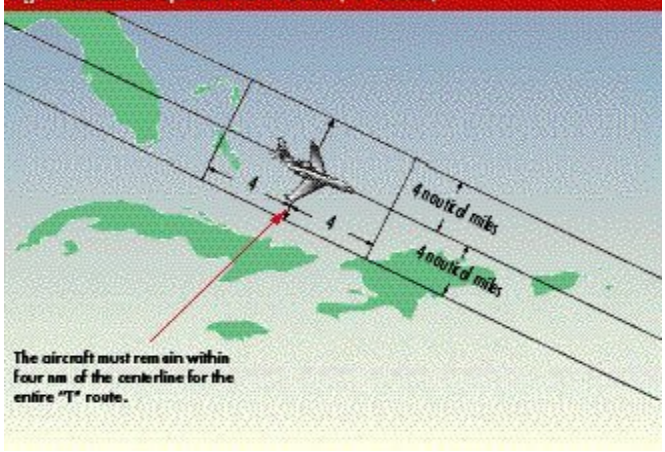
The following is good news for Caribbean operators. Air traffic activity continues to increase in the Bahamas/ Caribbean area. Airspace has been severely limited by a route structure based on traditional groundbased navaids and radar facilities. Introduction of GPS navigation has prompted Miami center to implement an RNAV-based route system designed to provide more direct routing in the Caribbean area.

Fixed RNAV routes are published by the State and referred to as "T" Routes. (Fig 5) These routes are not considered RNP routes (yet). Development was based on routes with widths that extend 4 nm either side of centerline at all points with no expansion of controlled/protected airspace at the 51 nm point as current VOR/DME criteria require.

They are considered "**special routes**" that require authorization until they become public (Phase II) later this year. Authorization can be obtained in the form of a "letter of agreement" between you and Miami ARTCC. These "T" routes are authorized for NON-VOR/DME RNAV systems only. If your aircraft uses an /E or /G equipment suffix and has at least dual IRUs, or if your aircraft is equipped with GPS RNAV systems authorized for enroute and terminal, but not for approach, you also meet the requirements. When Phase II is implemented, operations will be restricted to aircraft with proven navigation capabilities and having TCAS installed and operational.

You can achieve authorization for these "T" routes by first contacting Miami ARTCC (Tel: 305 716-1530). You will be asked for certain information that is required to enter into a letter of agreement between you and/or your company and Miami ARTCC. They require the name of your company, signatory and title, company point of contact and knowledge of the aircraft (and flightcrew) capability to navigate within a standard (+/-4 nm). In return, Miami Center will provide you with all the information necessary for your database (fix names, coordinates, airways etc.) in the form of an attachment to the letter of agreement. Two copies of the letter of agreement will be signed by the facility chief and you (one for you and one for Miami center). You can also order the "Caribbean Special RNAV Routes" chart from Jeppesen or confirm that you already have the waypoints in your FMS database.

Fig 5. Caribbean special RNAV routes ("T" routes)



Provisions for Accommodation of NonRNP10 Aircraft

(Aircraft Not Authorized RNP 10 or RNP 4).

Operators of NonRNP10 aircraft shall follow the practices detailed in 4a and 4b below.

a. Operators of NonRNP10 aircraft shall annotate ICAO flight plan Item 18 as follows: "STS/NONRNP10" **(no space between letters and numbers)**.

b. Pilots of NonRNP10 aircraft that are flight planned to operate or are operating **on WATRS Plus "L" and "M" routes** shall report the lack of authorization by stating "**Negative RNP 10**" in the:

- Atlantic portion of the Miami Oceanic CTA
- New York Oceanic CTA/FIR
- New York Atlantic High Offshore Airspace
- San Juan CTA/FIR
    - on initial call to ATC and...
    - in read back of clearance to descend from FL 410 and above. (See paragraph 4e below).
    - if approval status is requested by the controller. (See paragraph 8h below).

c. Operators of NonRNP10 aircraft shall **not** annotate ICAO flight plan Item 18 (Other Information) with "NAV/RNP10" or "NAV/RNP4", as shown in paragraph 7, if they have **not** obtained RNP 10 or RNP 4 authorization.

d. NonRNP10 operators/aircraft are able to file most WATRS Plus routes at any altitude. Some routes, however, may require special routing for NonRNP 10 aircraft. Check the WATRS Plus Webpage for related FAA Notices. NonRNP 10 operators are cleared to operate on preferred routes and altitudes as traffic permits. Aircraft that are authorized RNP 10 or RNP 4, however, will have a better opportunity of obtaining their preferred altitude and route because the 50 NM lateral separation standard is applied to those aircraft. 50 NM lateral separation is not applied to NonRNP10 aircraft.

e. NonRNP10 aircraft retain the option of climbing to operate at altitudes above those where traffic is most dense (i.e., at/above FL 410). To minimize the chance of conflict with aircraft on adjacent routes, NonRNP10 aircraft should plan on completing their climb to or descent from higher FLs within radar coverage.

f. All aircraft can enhance their opportunity to be cleared on their preferred route and altitude if they operate at non-peak hours, approximately 0100 to 1100 UTC.