RNP: The World of Required Navigation Performance

BY WALTER SHAWLEE 2

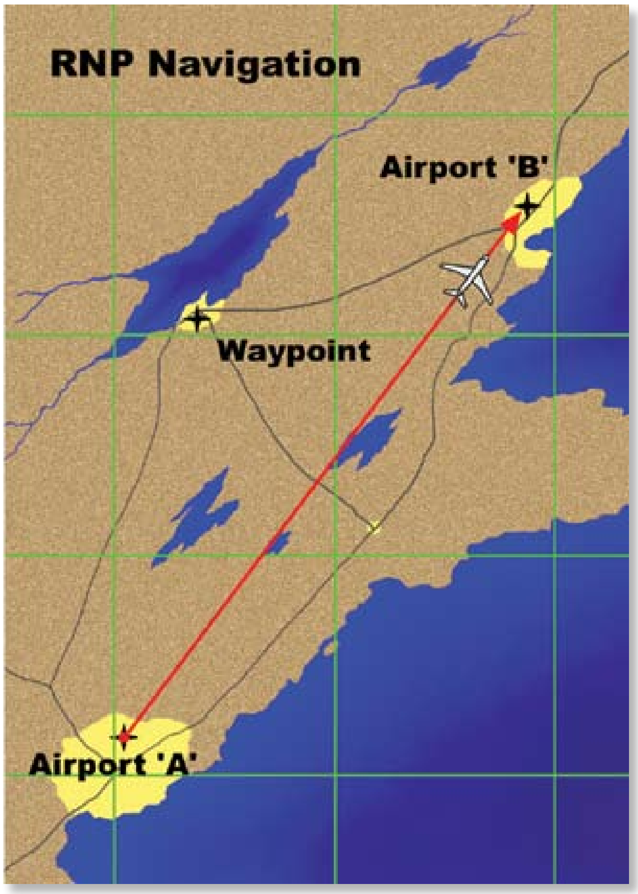

Illustration by Larry Stewart

Required navigation performance (RNP) is the practical application of advanced RNAV (area navigation) concepts to the existing airways infrastructure of the world. It replaces the earlier point-to-point, leg-based ADF/VOR/DME/ILS method of zigzag navigating and routing air traffic with a smoother direct flow model using GNSS (global navigation satellite system) as the primary navigation data source.

In essence, RNP attempts to make the cleanest straight line + constant radius turn route to everywhere, while allowing obstacle flexibility to the user where required.

In my hometown of Kelowna, British Columbia, it is already used by Westjet to provide a cleaner airport approach with noise abatement in all weather, and it saves about 5 percent on trip time and fuel costs.

While we have only the U.S. Navstar/GPS system as a fully operational GNSS constellation today, the Russian GLONASS system is being refreshed to make it fully operational worldwide by 2010, and the European Galileo system is scheduled to be on line between

2011 and 2012 (three to four years later than originally projected). China also has a regional system called Beidou, which may be extended for worldwide operation, and India's IRNSS is under development and scheduled for deployment by 2012.

A good potential exists for at least three globally deployed constellations within as little as four years.

RNP is a portion of the performance-based navigation model advanced by the International Civil Aviation Organization, the FAA and others. It essentially couples real-time nav-aid performance monitoring and alerting to GPS. The total uncertainty and absolute accuracy of this combination of avionics determines how accurately any given direct flight path could be flown and how closely aircraft can be spaced as a result. In essence, the additional concept here is containment, not just navigation — the aircraft must be placed within a distinct zone (for-aft and port-starboard) that can be well defined and maintained.

Not every aircraft system can fly to the highest standards. Today, RNP is principally a tool for controlling flow to high-density, high-traffic airports; so its real intent is in maximizing access for the best equipped, typically transport category aircraft. RNP will quickly affect every user, however. Over time, virtually all airport access will be governed by RNP capability, and other systems will be de-emphasized.

RNP approval guidance for flight operations are defined in FAA advisory circular AC90-101, and can be downloaded in full from www.airweb.faa.gov/Regulatory_and_Guidance_Library/rgAdvisoryCircular.nsf/0/821aca6a248d6aea862570ed00536340/$FILE/AC90-101.pdf.

Why Do People Want RNP?

Since the advent of GPS, it has been clear old IFR (instrument flight rules) flight routes often were inefficient and clumsy. IFR routes vector from nav aid to nav aid, not origin to destination. For a considerable period, there was no good alternate flight protocol for users to implement to take full advantage of GPS, especially for the transport world.

Older-generation nav aids lose accuracy over distance and can only give a single vector or distance (which is to the nav aid itself, not necessarily to the destination), not true position. In contrast, GNSS gives the same accuracy any distance from the destination (assuming no obstructions) and always gives true position, as well as vector and distance to the actual destination. As a result, RNP routes can be much more accurate, allow for more parallel flight tracks and aircraft spaced on the same track, and provide far better obstacle and approach routing.

The RNP route changes have several critical impacts: They shorten flight length and flight times (and fuel consumption, which is a big cost driver if you are pushing a 737 or 767), and they potentially allow more flights per unit hour at the airport, which is a critical infrastructure improvement issue. In addition, their approaches work much better around terrain obstacles and in inclement weather, providing distinct competitive advantages in must-fly and must-land situations for air carriers.

Taken together, these are compelling arguments for a change. Actual flight testing shows a marked improvement in successful take-offs and landings in bad weather that would not have been possible using previous techniques, and a significant improvement in throughput at each runway.

Just as outdated bridges have been newsworthy as a crumbling infrastructure topic, the entire flight management system worldwide has been under equally critical review, especially by the ICAO and FAA. Controllers are over-

Continued on following page

The Roadmap for the FAA's Transition Plans

• Near-term: Today to 2010

Realize the value of investments by operators in current aircraft and new aircraft acquisitions, FAA investments in satellite-based navigation, and conventional navigation infrastructure. The focus is on wide-scale RNAV implementation and the introduction of RNP for en route, terminal and approach procedures. The near-term strategy complements the agency's efforts to alleviate choke points at the 35 airports in the FAA's Operational Evolution Plan (OEP).

• Mid-term: 2011 to 2015

Shift to predominantly RNP operations for improving flight efficiency and airport access. The mid-term strategy will employ RNAV extensively to improve flight operations.

• Far-term: 2016 to 2025

Concentrate on performance-based operation through integrated required navigation performance (RNP), required communications performance (RCP) and required surveillance performance (RSP); optimizing airspace, automation enhancements; and modernization of communications, navigation and surveillance infrastructures.

REQUIRED NAVIGATION PERFORMANCE

Continued from page 45

loaded, access is not optimal, airports are congested, and flights are chronically late, which has a bad cascading system effect. Couple that with old and often seriously inadequate ground-based nav aids (DME, VOR, ILS, ADF and markers) all in need of expensive updating, and you have some of the economic and political factors pushing adoption of RNP.

If the planned international GNSS constellations all are deployed, there also will be deep backup for this technology, rather than just a single system financially underwritten by a single country. The performance impact of this change is profound and makes the reliance on a single space deployed system less troubling for everyone involved.

Digging Deeper

The use of RNP means the aircraft must have suitable navigation, monitoring and alerting systems installed, tested and certified, which is not an easy undertaking. Simply installing GPS is not sufficient. If the intent is also to have a long-term system, compatibility with more than a single GNSS constellation is required, which might not be easy to accomplish today.

A multi-sensor system with multi-constellation capability is clearly an operational advantage long-term, especially for international flight. Transport systems already are utilizing GNSS updating of their INS (inertial navigation system) to provide an additional layer of online backup without resorting to lower-precision, ground-based systems.

Different flight-path locations require different packing density and must take into account issues such as winds, localized weather avoidance and potential path drift at high flight speeds. Currently defined trans-Atlantic and trans-Pacific flight paths mandate as much as a 50 to 100 nm lateral spread over these "parallel" long routes to ensure safety under all weather conditions, even though RNP navigation may be defined on the route as 10 nm accuracy.

The RNP categories are based on how accurately (and, therefore, how closely) aircraft can be spaced in flight at the same flight level. RNP performance is specified as RNP-n, where the number indicates the accuracy boundaries fore-aft and port-starboard from the center aircraft location in nautical miles. The aircraft must be able to correctly position itself within this envelope 95 percent of the time to be able to fly this category. If the aircraft position error is equal to or more than double this interval (2n), an alert must be generated.

If weather conditions or flight errors occur in two parallel flight paths that happen to put them on a potential collision course, additional space must be provided to allow correction, and thus the lane spacing cannot be truly adjacent. Currently defined RNP-4 category flight (a zone actually 8 nm in total width, or potentially up to 16 nm if in an error condition) results in practical parallel lanes of no closer than 30 nautical miles, center-to-center; RNP-10 flight lanes can be no closer than 50 nm spacing. An RNP-4 aircraft could stray up to 8 nm laterally off its intended course at the point of error detection; therefore, two parallel worst-case aircraft can potentially close within 14 nm (30-8-8=14).

So far, at least RNP-0.3, RNP-4, RNP-10 and RNP-12.5 are defined and used in practice. In reality, any interval that could be accurately and repeatably determined could be potentially used. The RNP categories essentially define the containment boundary of the aircraft in flight.

Airframe manufacturers, such as Boeing and Airbus, already can deliver ships with RNP-0.3 capability, and are moving to RNP-0.1 or RNP-0.15 cer-

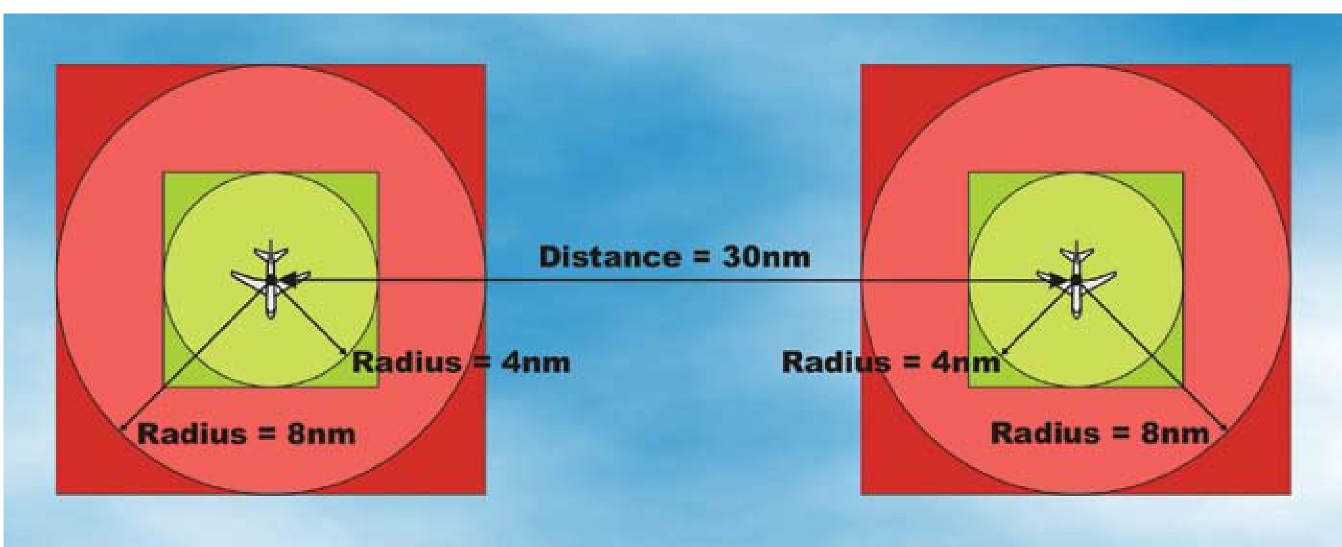

Illustration by Larry Stewart

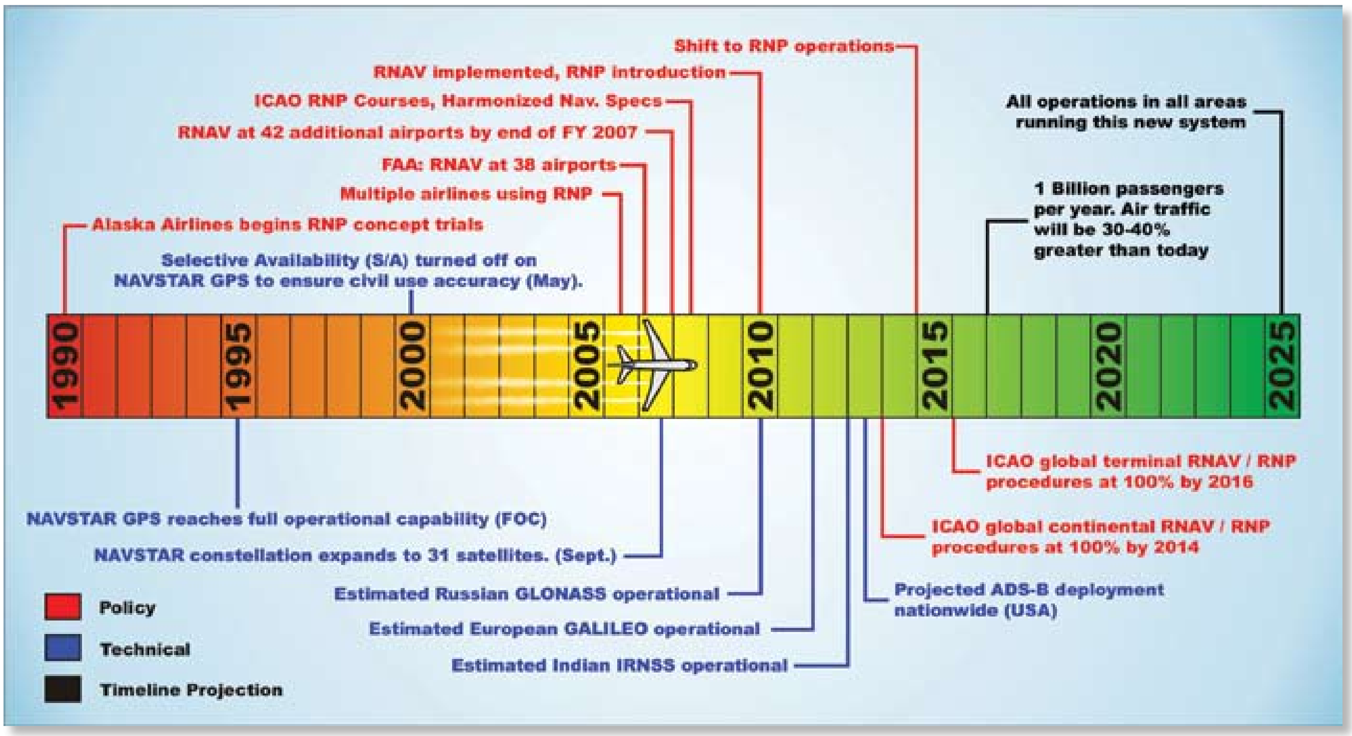

Illustration by Larry Stewart

tification in the future, as they foresee this being a pivotal feature for future busy airport access.

The RTCA (Radio Technical Commission for Aeronautics) has developed a standard for this general RNP concept called DO-236B, "Minimum Aviation System Performance Standards: Required Navigation Performance for Area Navigation." This is useful for anyone wanting to study this technology in detail, and should be studied by any installing agency.

Enter NextGen

The RNP aircraft-in-transit concept cannot be fielded alone, but rather has to be part of a larger avionics strategy with some accurate way of actually monitoring and controlling flight-path spacing.

Enter NextGen (Next Generation Air Transportation System) and the technology called automatic dependent surveillance-broadcast, or ADS-B. This also will use GNSS as the primary data source and provide a way of displaying both to controllers and adjacent aircraft their positions, vectors and possible conflicts. Here, the individual aircraft sends its GPS/GNSS-derived position to the system, and the data is integrated with such useful information as terrain and obstacles, and re-sent.

This already has been extensively field-tested in Alaska, and is now being widely deployed via the recently awarded contract to the team headed by ITT.

Practical use of tightly packed RNP laneways requires regular position fixing by some method, whether automatically by data-link or by scheduled pilot reporting over existing com channels. It also requires control and measurement of true airspeed to make fore and aft spacing possible. I strongly suspect pilots also will want some type of potential collision detection and avoidance technology in this environment, especially if an aircraft in their vicinity faults into an error condition while in their RNP airspace.

Increased Service Burden

One certainty of an RNP-driven airspace is, the requirement for higher quality and more modern avionics, as well as their regular overhaul and calibration, will increase dramatically. This will require a mindset change in owner/operators to be much more aware of their avionics systems and their condition.

Maintenance facilities also will have to meet a higher standard of system performance and faster turn-around to ensure aircraft uptime. Service will need to include actual accuracy determination of the GPS/GNSS system, as well as testing of GPS/GNSS antennas for functionality and gain, and microwave antenna feed lines for loss — all areas not currently well addressed.

To fly under RNP procedures, an aircraft must be fitted with dual FMS (flight management systems) and dual GNSS positioning systems as a minimum, and undergo a formal testing and certification process. In this transitional period, additional land-oriented nav aids also are required onboard. In-flight loss of navigation accuracy as detected

Continued on following page

REQUIRED NAVIGATION PERFORMANCE
Continued from page 47

by the FMS must alert the flight crew that an FTE (flight technical error) has occurred and they are no longer able to proceed under RNP rules. This would require a fallback to secondary nav aids and more conventional IFR procedures.

Some troubling aspects of RNP bear examining. First, it is unclear what effective action an aircraft really can take in a fully converted RNP world if it experiences significant avionics failure in flight. This could cause the aircraft to disappear from ADS-B monitoring systems (and with no true radar backup, it suddenly becomes a real flight threat) or drift out of a tightly controlled and closely spaced flight stream.

If land-based nav aids are de-emphasized, it is unclear what secondary system the aircraft could effectively use for navigation. A good argument can be made for land-based Loran and other systems as a fallback secondary system to augment the primary GNSS, and/or the use of a third GNSS system for voting, as is done on the space shuttle systems.

The potential deployment risk in the future will be for dollar-driven politics to override practical safety, leading to an abandonment of everything but GPS/GNSS technology. Any trend of this kind should be carefully monitored.

The total reliance of GNSS is a problematic concept from a fault-correction viewpoint. If a single DME or VOR station goes down, all is not lost for navigation, but a single satellite in a bad geometry situation can have serious repercussions for a very wide area of controlled airspace, especially under tight RNP-0.3 conditions. Further, while one can drive out in an old '67 Chevy to fix the defective beacon, it is not so trivial to fix a satellite in orbit — something the Russians discovered with GLONASS, and a situation the United States discovered with its space shuttle program setbacks.

Space is not a friendly environment and, in fact, is wickedly hard to reach. It is also bathed in searing radiation and all kinds of unforgiving ballistic objects outside the protection of Earth's atmosphere — not an installation or service territory for the faint of heart.

Any future program so dependent on a single keystone technology should be both highly secured and quickly restored in the event of failure. Solar flares, CME (coronal mass ejections), meteor showers and deliberate sabotage both from space and from ground-support facilities, software glitches and failures, equipment failure, funding availability, and deliberate signal jamming must be considered in the real-world deployment given the state of world affairs and the reality of space.

The shift to RNP navigation is a big conceptual leap for flight crews, controllers and service agencies. It also will be even less forgiving of any incapacity, error or neglect (as the famous poster about aviation safety notes), and will require a much higher standard of performance from everyone involved.

This is clearly the time to start planning how it will affect you, no matter what role you will play in the future RNP airspace.

If you have comments or questions about this article, send e-mails to avionicsnews@aea.net.

Important Web Resources

• See the excellent Westjet video on RNP at:
http://video.google.com/videoplay?docid=-5284773282371819535

• FAA RNP Links:
www.faa.gov/news/fact_sheets/news_story.cfm?newsId=8768

www.faa.gov/about/office%5Forg/headquarters%5Foffices/avs/offices/afs/afs400/afs410/rnp

www.faa.gov/about/office_org/headquarters_offices/ato/service_units/enroute/oceanic

• Advisory circular AC90-101:
www.airweb.faa.gov/Regulatory_and_Guidance_Library/rgAdvisoryCircular.nsf/0/821ACA6A248D6AEA862570ED00536340?OpenDocument

• FAA Deployment schedules:
www.faa.gov/news/fact_sheets/news_story.cfm?newsId=8768

• ADS-B Implementation:
www.flttechonline.com/Current/DOT%20IG%20Says%20US%20ADS-B%20Implementation%20Faces%20Myriad%20of%20Risks.htm

Avionics News Archives

For easy access to the Internet sites provided in "Important Web Resources" (at left), visit www.aea.net/avionicsnews, where you can simply click on these same website addresses, which we have provided as links in a pdf of this article.