PERFORMANCE-BASED NAVIGATION:

RNAV & RNP In the NAS

ALPA pilot representatives are playing key roles in helping to spread two important nav concepts that already are increasing the safety, capacity, and efficiency of the U.S. air transportation system.

By Capt. Brian Townsend (America West), Chairman, ALPA National Airspace System Modernization Team

How about some good news about the U.S. airline industry for a change? Here's some: In a win-win effort that benefits pilots, their airlines, their passengers, the FAA, major U.S. airports, and local communities, the FAA and the aviation industry, including ALPA, are working collaboratively to modernize the U.S. National Airspace System (NAS) to handle a volume of air traffic that has recovered to *and surpassed* pre-9/11 levels. The stakeholders' broadly stated goal is to accommodate that demand while improving safety, security, and efficiency.

Within that context, performance-based navigation is an emerging concept that holds great promise for accomplishing the goal. As its enabling subelements—area navigation (RNAV) and required navigation performance (RNP)—continue to evolve, a system that ultimately provides benefits to all airspace users in all phases of flight will evolve as well.

Performance-based navigation is defined as navigation along a route, on a procedure, or in an airspace, in which the operating aircraft must comply with specified performance requirements. This is a fundamental shift from a navigation paradigm that specifies equipment types and technologies. RNAV and RNP define specified levels of performance, functionality, and capability as agreed-upon navigation standards.

In July 2003, the FAA published the *Roadmap for Performance-Based Navigation*, which was created in collaboration with the aviation community through the Terminal Area Operations and Aviation Rulemaking Committee, now known as the Performance-Based Operations Aviation Rulemaking Committee (PARC). This document outlines the FAA's strategy for implementing performance-based navigation. The FAA has also developed an update for mid-2006 to reflect new accomplishments and future goals.

The *Roadmap* defines three planning periods for implementing performance-based navigation: near-term (2006–2010), mid-term (2011–2015), and far-term (2016–2025). In each of these planning periods, operational milestones and implementation strategies for each phase of flight are described. For example, in the near term, implementing RNAV Standard Instrument Departures (SIDs) and Standard Terminal Arrival Routes (STARs) will be a high priority at the busiest U.S. airports.

ALPA role

Why should ALPA members pay attention to the transformation under way?

First and foremost, for safety's sake: RNP can provide a precision approach to all runway ends—no more "dive and drive" profiles. RNP approaches can increase NAS and airport capacity by providing precision approaches to runways that previously had no instrument approaches or only had approaches with much higher minimums.

Second, economic benefits: Greater capacity and efficiency in the NAS may lead to healthier airlines and more ALPA pilot jobs.

In the spirit of ALPA's 75 years as "Pilots in Command—Strong, Focused, and Safe," our safety representatives will remain the vanguards of implementing future technologies and procedures. We are not resistant to change and progress, but they must be achieved with a safe and pragmatic approach.

ALPA volunteers are playing an important role in the monumental task of transforming our NAS to the Next Generation Air Transportation System (NGATS—see page 14). Our dedicated pilot air safety representatives have established themselves as experts in subject areas, and the FAA and industry welcome their insight and experience.

Much of the RNAV and RNP work

From Here to Engats

You've heard of Engats, right? You know, the Next Generation Air Transportation System—NGATS, pronounced EN-gats. The U.S. air transportation system of

2025—more efficient, and even safer, than today's. A system built on satellite-based comm, nav, and surveillance, accommodating even more air traffic with tighter airspace use based on more precise flight and position reporting. A system that will employ technology and procedures that, in some cases, have not even been imagined yet.

"The way I see it," an aviation industry insider observed recently, "is that we have a lot of effort going on in the near-term to improve the NAS [National Airspace System]—stuff like the FAA's Operational Evolution Plan [OEP, a 10-year plan to improve air traffic control and air traffic management, scheduled to be completed in 2010]. The folks in the FAA's Air Traffic Organization are not only running the U.S. ATC system 24 hours per day, but they're also trying to upgrade and modernize the NAS while they're at it.

"At the other end of the time line is NGATS—almost 20 years away. The people who are working on NGATS are trying to work backward to figure out how to get there from here. The folks working on the near-term stuff are also trying to look farther into the future. In between now and NGATS is a big, blank space on the chart that I like to call, '…and a miracle happens.'"

The aviation industry rep, a genuine mover and shaker, was speaking at a joint meeting of the ALPA National Airspace System Modernization (NASMOD) Team and the ALPA Air Traffic Services (ATS) Group. In certain respects, the ALPA structure reflects that of the FAA regarding ATC and NASMOD. The Association's NASMOD Team, chaired by Capt. Brian Townsend (America West), and ALPA's ATS Group, chaired by Capt. Larry Newman (Delta), enjoy a good deal of interaction between themselves and the overall ALPA Air Safety Structure.

The NASMOD Team, which is an ALPA Presidential Committee and thus reports directly to ALPA's President, has several projects under way. Some involve ALPA representation on important government/industry groups dealing with NASMOD issues, including Automatic Dependent Surveillance-Broadcast (ADS-B) and unmanned aerial systems (UAS).

The ATS Group handles several projects that are definite stepping-stones to the future; two involve San Francisco International Airport (SFO), the poster child for geographically and environmentally constrained major U.S. airports—two sets of closely-spaced parallel runways, visibility often too low for visual approaches, and little likelihood of ever being permitted to build additional runways. SFO is the tail that wags the dog in certain aspects of efforts to increase airport capacity while maintaining a high level of safety. The ATS Group projects include

- SFO simultaneous offset instrument approaches (SOIA),
- SFO required navigation performance (RNP) parallel approach transition (RPAT),
- intersecting runway operations, and
- airspace redesign in conjunction with new runways and/or RNAV arrivals and departures.

SFO also plays a starring role in a major project of ALPA's Aircraft Design and Operations Group—wake vortex hazards. One of the key constraints on airport and airspace capacity and efficiency is the spacing between aircraft required to avoid the hazards of wake vortices.

The air transportation system includes not only airspace, aircraft, pilots, and air traffic controllers, but airports as well. ALPA's Airport Ground Environment Group supports projects that directly affect the safety, efficiency, and capacity of airports now and in the future, such as runway friction measurement, runway incursion prevention, and ground deicing and anti-icing.

ALPA Executive Air Safety Chairman, Capt. Terry McVenes (US Airways), oversees three major projects that arch over all aspects of airline operations—Safety Management Systems (SMS), Flight Operations Quality Assurance (FOQA) Programs, and Aviation Safety Action Programs (ASAP). SMS will become increasingly important as a tool to assess risk at all levels of the U.S. and Canadian air transportation systems and to point the way to reducing that risk. Data from FOQA (digital flight data recorder information used in nonpunitive ways) and ASAP (voluntary, confidential employee reports) will continue to provide feedback from "life on the line."

Between now and NGATS "a miracle [may] happen." It's surprising what kind of miracles you can achieve, however, with adequate funding, lots of hard work, and your ALPA safety reps paying attention to the details while not losing sight of the grand vision.—*Jan W. Steenblik, Technical Editor*

ALPA's robust Air Safety Structure is directly involved in virtually every aspect of modernizing the U.S. air transportation system.

takes place through the PARC. Capt. Pedro Rivas (Delta) is ALPA's representative to this rulemaking committee. He is supported by First Officer Greg Saylor (Delta), Capts. Alan Campbell (Delta, Ret.), Dave McKenney (Delta), Shawn Pruchnicki (Comair), D.R. Smith (Alaska), and Ana Vegega (United), and me, Capt. Brian Townsend. Staff engineers Kevin Comstock, Mark Cato, and Jim Duke and others in ALPA's Engineering and Air Safety Department provide invaluable support to the ALPA NASMOD Team.

RNAV

RNAV enables pilots to fly point-to-point on any desired flightpath within the coverage of referenced navigation aids and / or within the capability of self-contained systems. Equipment that enables RNAV operations is already "standard" on many modern airliners. Inertial reference systems (IRS) with distance-measuring equipment (DME) or the satellite-based Global Positioning System (GPS) are two examples of equipment suites that enable RNAV. In addition to enabling RNAV SIDs and STARs, such equipment enables pilots to fly directly to any desired waypoint or to fly a tailored path around convective weather.

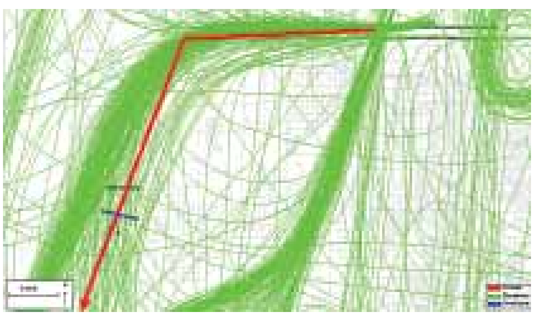

Figure 1: LAS flight tracks outside of noise portal.

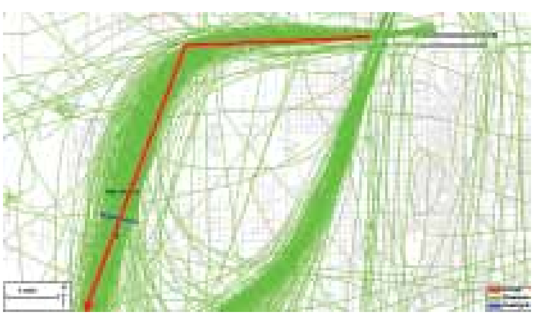

Figure 2: Flight tracks "on target" after departure procedure revision.

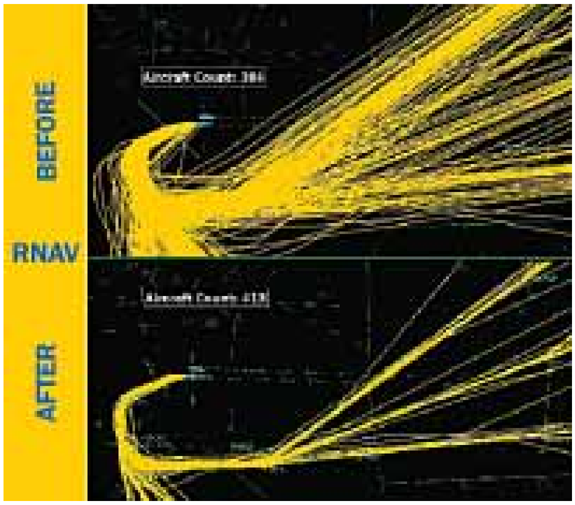

Figure 3: ATL "loop" departure tracks.

Pilots can use an RNAV procedure (SIDs, STARs, etc.) by "line selecting" it in the flight management computer (FMC). After being cleared by ATC, the flight crew is able to execute the procedure without having to rely on traditional radar vectors or ground-based navaids.

The procedure is not executed in a vacuum, however. Ongoing communication between flight crew and controller is still a vital necessity in case radar vectors are needed to ensure safe separation from other aircraft. As soon as the airplane is clear of conflict, it can then rejoin the procedure at any fix along the route.

RNAV STARs and SIDs are currently being flown at several U.S. airports, and implementing more at the busiest U.S. airports is a priority for the near term. RNAV procedures enhance situational awareness of pilots, reduce workload for controllers, and provide repeatable, accurate ground tracks.

Las Vegas McCarran International Airport (LAS) has already seen benefits from RNAV operations. One of the first U.S. airports to use RNAV procedures, LAS has successfully applied several "lessons learned" in an effort to revise them for maximum efficiency.

For example, departure routes at LAS were recently adjusted, leading to two significant benefits to the LAS TRACON, the airlines, and the surrounding community. The original RNAV ground track, as depicted in Figure 1, passed over a noise-sensitive area. The ideal "portal" through which aircraft needed to fly for noise abatement is depicted in blue. With RNAV, the task of adjusting the procedure to satisfy that constraint was vastly simpler than it would have been had the procedure been flown in reference to ground-based navaids.

As an added benefit, the corrected ground track (see Figure 2) was found to be nearly 3 miles shorter, on average, saving fuel and reducing flight time. The reduced fuel burn as a result of the shortened lateral segments, multiplied by hundreds of departures per day, quickly add up to big savings. One airline estimated it would glean $500,000 in overall savings in operating costs per year.

LAS has also implemented STARs that provide efficient routing around environmentally sensitive areas and enhance safety by reducing the need for rapid descents and uncomfortable intermediate level-offs.

Atlanta Hartsfield Jackson International Airport (ATL) has also begun using RNAV. Thirteen RNAV SIDs were established at ATL in April 2005. Each can be used in either of ATL's main runway configurations, and all can be used from either runway.

ATL originally had eight departure fixes. After the RNAV SIDs were implemented, five additional departure fixes became available, adding a significant amount of operational flexibility.

Also, distances flown on departure have been reduced for certain flows leaving ATL. "Loop" departures, e.g., flights from an easterly departure runway to a westerly destination, have been shortened by almost one nautical mile per flight. Figure 3 depicts loop departures at ATL before and after RNAV implementation.

RNAV departures at ATL have produced savings in other areas as well—e.g., by reducing the number and length of air–ground–air communications. Less frequency congestion translates directly into less time spent in level flight waiting for clearance to climb and / or to proceed on course. Also, a much more efficient paradigm for handoffs between ATL Terminal and Center controllers has been created. As a result, level-off time at 10,000 feet has been reduced by as much as 70 percent.

Four RNAV arrivals also became operational at ATL in 2005. They overlie downwind legs that were historically assigned via ATC radar vectors. The new RNAV arrivals have reduced distances flown by as much as 4 nautical miles per flight in certain traffic configurations.

As Table 1 shows, RNAV has greatly reduced pilot-controller communica-

Position	Reduction in number of comms	Reduction in content of comms
Approach	*50 %*	*30%*
Tower	*—*	*22%*
Departure	*40%*	*60%*

Table 1: Pilot/controller voice communication reduction at ATL.

tions in the approach and departure phases of flight at ATL. The *number* of communications decreased by as much as 50 percent, and the *content* has decreased by as much as 60 percent. Procedures that used to require several heading and speed instructions can now be executed with one RNAV clearance. Fewer hear-back/read-back errors lead to fewer pilot deviations.

The tower, which still clears all flights for takeoff or landing, has not seen a reduction in the *number* of communications because the number of flights has not changed. However, the *length* of these communications has been significantly reduced.

Similar reductions in communications have been observed at other airports using RNAV procedures.

The overall cost savings add up at ATL. One airline estimates that airlines will save approximately $30 million annually in delay reductions alone. Mileage reductions, early time to climb, and quicker departures total more than $16 million in annual savings to the users.

RNP

RNP is the second key component of the U.S. transition to a performance-based NAS. RNP routes are, for all intents and purposes, RNAV routes that

Figure 4: Palm Springs special RNP SAAAR approach.

require a certain level of conformance assurance built into the procedure. Onboard avionics must alert participating pilots if the navigation system performance required for the procedure is not being maintained. Consequently, pilots flying an RNP procedure can navigate with a much higher degree of accuracy and path integrity than they can achieve with RNAV alone. This additional assurance reduces the need for controller intervention. RNP procedures are established where unique airspace needs are a factor and, like RNAV procedures, are not constrained by the location of ground-based navaids.

The overwhelming advantages of RNP procedures were seen immediately in approaches and were found to enhance safety, capacity, and efficiency. Several approach procedures using advanced RNP criteria have been published in the United States, and several more are being developed. These RNP approach procedures require Special Aircraft and Aircrew Authorization (SAAAR), similar to the authorization required for Category II and III ILS approaches.

The FAA has recently published public criteria for implementing RNP SAAAR approaches. Before those criteria were established, RNP SAAAR usage was limited to company-specific special procedures, tailored to unique operations.

One example of an airline-specific procedure involved Alaska Airlines at Palm Springs International Airport (PSP). The airline collaborated with the FAA to develop a special RNP SAAAR procedure at PSP that provides an alternative to a VOR/GPS approach with circling (see Figure 4). Because of mountainous terrain around PSP, the VOR/GPS approach required 3 miles of visibility.

The new straight-in RNP SAAAR approach requires ¾ mile visibility, saves almost 30 miles per flight in IMC conditions, and is safer.

Alaska Airlines has conducted the PSP RNP approaches more than 345 times and has documented more than 29 instances when flights that would otherwise have been forced to divert were instead able to land at PSP. The results—$145,000 saved in diversion costs and 4,500 passengers who didn't have to go "Greyhound" from ONT.

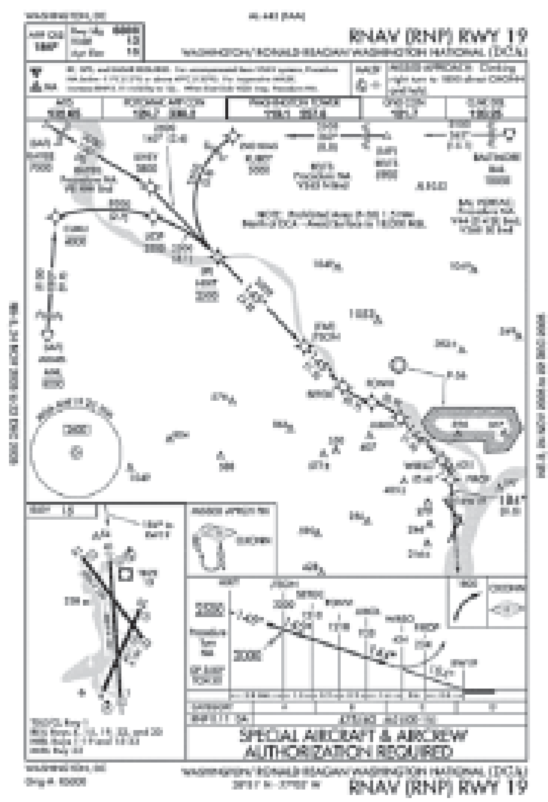

Figure 5: Washington National Airport's RNP SAAAR approach.

Similar benefits are available to the broader aviation community with the public version of the RNP SAAAR procedure implemented in December 2005.

Another key site where RNP SAAAR has been implemented is Washington Reagan National Airport (DCA). The RNP procedure (see Figure 5) overlies a visual approach to Runway 19, an approach that follows the Potomac River. This approach involves a number of turns at low altitudes, and adding curved legs and lateral navigation guidance via RNP will allow pilots to land with considerably lower cloud ceilings and visibility than currently required, increasing airport access during marginal weather. This capability has already resulted in savings from reductions in holding and diversions, with a number of saves already observed, as reported by airline representatives and the Potomac TRACON. Safety is enhanced as a result of the positive lateral and vertical guidance that the procedure provides.

The procedure at DCA may be used by any operator who can meet specific FAA requirements for aircraft navigation performance and pilot training. Alaska Airlines is the first airline that the FAA authorized to use the RNP procedures at DCA. Furthermore, because the RNP approach is an overlay of an existing approach, environmental concerns have already been satisfied and possible encroachments on Prohibited Area P56 around downtown Washington, D.C., have been dramatically reduced.

RNP SAAAR procedures at one airport may also facilitate operations at a nearby airport. Midway (MDW) and O'Hare (ORD) International Airports are one such pair example. Whenever MDW is using Runway 13C for arrivals and ORD traffic is departing on Runway 14R and arriving on Runway 22L, a potential traffic conflict exists. The missed approach path for MDW Runway 13C conflicts with the missed approach path for ORD Runway 14R. The MDW Runway 13C approach path also interferes with the departure path for ORD Runway 22L, as depicted in Figure 6. These operational constraints force delays into MDW's and ORD's respective arrivals and departures and can create bottlenecks during periods of peak traffic.

This runway configuration does not represent the norm, but the traffic conflict described results in nearly 10,000 delay minutes per year at MDW and nearly 100,000 at ORD. By developing a curved RNP approach with low enough minima at MDW, these flows will no longer conflict with each other. The proposed RNP SAAAR approach to MDW Runway 13C is depicted in Figure 6.

Plans are in place to implement numerous RNP approaches at U.S. airports over the next several years. Applications of RNP that are expected to provide significant benefit include

- dependent closely spaced parallel runway operations,
- simultaneous converging approaches, and
- airspace de-confliction.

The RNP concept also will be used to (1) facilitate access to runways with dangerous terrain and airports with no existing instrument approaches, and (2) provide lateral and vertical guidance to runways that had only circling approaches previously. Another important safety benefit related to RNP procedures development is the potential reduction of tailwind landings at airports that have few ILSs because of economic or airspace constraints. While these newly designed procedures will increase air-

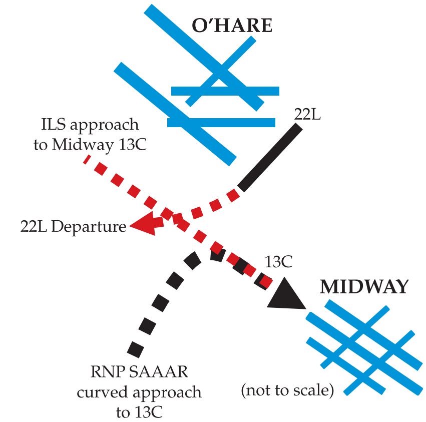

Figure 6: MDW/ORD conflict depiction.

space and airport capacity, the target level of safety will be achieved through such elements as pilot training, aircraft performance, and ATC surveillance. As the demand for NAS services continues to grow, RNP will become an increasingly key component of the U.S. strategy for keeping up with this demand.

Build it and they will come

Other locations where RNAV procedures are currently in use include Dallas-Fort Worth, Philadelphia, and Washington Dulles in northern Virginia. They are already providing critical benefits to operators and controllers alike. During the next several years, roughly 200 additional RNAV procedures are scheduled for implementation at the 35 busiest U.S. airports. Supplementing these SIDs and STARs with RNP capability will further help maximize use of limited airspace in the face of ever-growing demand.

The United States is not alone in its efforts to handle burgeoning air traffic. Numerous nations are working to increase efficiency and safety in their airspace, and performance-based navigation—RNAV and RNP—will be a part of those efforts. Global harmonization will become increasingly important as those programs continue to mature.

Continued Coverage

Your ALPA NASMOD Team will continue to publish articles in *Air Line Pilot* related to the changes under way in the limited resource we operate in, the NAS. We will inform and update you on such emerging technologies as unmanned aerial systems, automatic dependent surveillance-broadcast (ADS-B), and RNP parallel approach transitions (RPAT).

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