NextGen Goal: Performance-Based Navigation

RNAV and RNP Evolution Through 2025

The Next Generation Air Transportation System (NextGen) is the Federal Aviation Administration's (FAA) plan to modernize the National Airspace System (NAS) through 2025. Through NextGen, the FAA is addressing the impact of air traffic growth by increasing NAS capacity and efficiency while simultaneously improving safety, reducing environmental impacts, and increasing user access to the NAS. To achieve its NextGen goals, the FAA is implementing new Performance-Based Navigation (PBN) routes and procedures that leverage emerging technologies and aircraft navigation capabilities.

What is Performance-Based Navigation?

PBN is a framework for defining performance requirements in "navigation specifications." PBN framework can be applied to an air traffic route, instrument procedure, or defined airspace. PBN provides a basis for the design and implementation of automated flight paths as well as for airspace design and obstacle clearance. The two main components of PBN framework are Area Navigation (RNAV) and Required Navigation Performance (RNP). Once the required performance level is established, the aircraft's own capability determines whether it can safely achieve the specified performance and qualify for the operation.

As NextGen continues to evolve, commitments such as those formerly detailed in the *Roadmap for Performance-Based Navigation* have been incorporated into the NextGen Implementation Plan. In fact, several NextGen solutions are dependent on RNAV and RNP implementation as enabling technology in the NAS, including:

- Trajectory-Based Operations
- Arrivals/Departures at High-Density Airports
- Flexible Terminals and Airports
- Optimized Profile Descent

These advances in aircraft capabilities and air traffic system operations support the transition to performance-based operations, including RNAV and RNP.

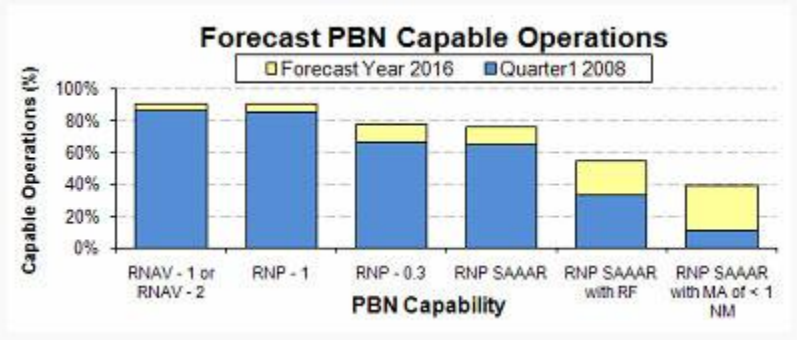
What Is RNAV?

RNAV enables aircraft to fly on any desired flight path within the coverage of ground- or spaced-based navigation aids, within the limits of the capability of the self-contained systems, or a combination of both capabilities. As such, RNAV aircraft have better access and flexibility for point-to-point operations.

What Is RNP?

RNP is RNAV with the addition of an onboard performance monitoring and alerting capability. A defining characteristic of RNP operations is the ability of the aircraft navigation system to monitor the navigation performance it achieves and inform the crew if the requirement is not met during an operation. This onboard monitoring and alerting capability enhances the pilot's situation awareness and can enable reduced obstacle clearance or closer route spacing without intervention by air traffic control.

Certain RNP operations require advanced features of the onboard navigation function and approved training and crew procedures. These operations must receive approvals that are characterized as Special Aircraft and Aircrew Authorization Required (SAAAR), similar to approvals required for operations to conduct Instrument Landing System Category II and III approaches.



(From PBN Capability Report, MITRE 2008)

Global Support

The aviation community is pursuing the benefits of PBN through the implementation of RNAV and RNP-based air traffic routes and instrument procedures. In March 2007, the International Civil Aviation Organization (ICAO) completed the *PBN Manual* which involved

collaboration with technical and operational experts from several countries. The ICAO *PBN Manual* provides a long-anticipated global harmonization of RNAV and RNP requirements – a leading priority of the aviation stakeholder community worldwide. To promote global awareness and understanding of the new *Manual*, FAA and the European Organization for the Safety of Air Navigation (EUROCONTROL), with the ICAO PBN Program Office, have presented seminars throughout the ICAO Regions. All of the10 planned seminars were completed as of December 2008.

Benefits

RNAV and RNP specifications facilitate more efficient design of airspace and procedures which collectively result in improved safety, access, capacity, predictability, operational efficiency, and environment. Specifically, improved access and flexibility for point-to-point operations help enhance reliability and reduce delays by defining more precise terminal area procedures. They also can reduce emissions and fuel consumption.

RNAV procedures can provide benefit in all phases of flight, including departure, en route, arrival, approach, and transitioning airspace. For example, Standard Terminal Arrivals (STARs) can:

- Increase predictability of operations
- Reduce controller/aircraft communications
- Reduce fuel burn with more continuous vertical descents
- Reduce miles flown in Terminal Radar Approach Control (TRACON) airspace
- Reduce interaction between dependent flows in multiplex airspace

Phoenix (PHX) RNAV Arrivals

Since the implementation of two RNAV STARs at PHX in October 2006, significant benefits have been noted: 38 percent reduction in the time aircraft remain in level flight; user benefit savings estimated at $2 million annually; and reductions in carbon dioxide emissions estimated at 2500 metric tons annually.

Similarly, RNAV Standard Instrument Departures (SIDs) can:

- Reduce departure delay via diverging departure routes off the runway
- Reduce interaction between dependent flows
- Reduce controller/aircraft communications
- Reduce miles flown in TRACON airspace
- Increase predictability of operations

Atlanta (ATL) RNAV Departures

Atlanta RNAV SIDs have achieved fuel savings due to reduced departure delays of more than 2.5 minutes per flight. Annual fuel savings are estimated at $34 million, with cumulative savings of $105 million from 2006 through 2008.

Dallas-Fort Worth (DFW) RNAV Departures

DFW departures on initially diverging routes (fanned departures) have resulted in improved separation efficiency and increased capacity by 11 to 20 operations per hour, with cumulative savings estimated of $30 million from 2005 through 2008.

San Diego (SAN) RNAV Departures

An RNAV SID at San Diego is projected to yield fuel and emissions savings of 4.5 gallons and 95 pounds of carbon dioxide per flight, which equates to reduction of nearly 1800 metric tons of emissions annually.

RNP SAAAR

RNP SAAAR approach procedures offer design flexibility and enhanced performance, allowing us to mitigate obstacles and de-conflict traffic as illustrated in the RNP SAAAR approach at Dekalb-Peachtree Airport (PDK) depicted below.

RNP containment provides separation from obstacles

Similarly, Ronald Reagan Washington National Airport's RNP SAAAR approach to Runway 19 was designed to avoid the protected areas near the nation's Capital and provide approved carriers with the ability to land in situations of decreasing visibility due to weather.

To date, FAA has authorized more than 265 RNAV procedures at 90 airports in 30 states.

RNAV 2005 – March 2009 [Cities in **bold** have OEP airports]

- Alaska (Adak, Akhiok, Anaktuvuk Pass, Anchorage, Arctic Village, Atka, Golovin, Juneau, Kaltag, Ketchikan, King Cove, Nondalton, Palmer, Perryville, Petersburg, Ruby, Sitka, Willow)
- Arizona (Glendale, Goodyear, **Phoenix**, San Carlos, Sedona, Tucson)
- California (Alturas, Borrego Valley, California City, Long Beach, **Los Angeles,** Mojave, Oakland, **San Diego, San Francisco**, Santa Monica)
- Colorado (Holyoke, Lake County, Nucla, Rifle, Walden)
- Florida (Boca Raton, **Ft. Lauderdale,** Ft. Myers, **Miami,** Naples, **Orlando, Tampa**, West Palm Beach)
- Georgia (**Atlanta**, Augusta)
- Hawaii (Hana)
- Idaho (Arco, Driggs, Grangeville, Hailey)
- Illinois (**Chicago**)
- Kentucky (**Covington**, Louisville)
- Maryland (**Baltimore**)
- Massachusetts (**Boston**, Nantucket)
- Minnesota (**Minneapolis-St. Paul**)
- Montana (Colstrip)
- Nevada (Carson City, **Las Vegas**, Reno)
- New Hampshire (Manchester)
- New Jersey (**Newark**, Teterboro)
- New York (**New York**)
- North Carolina (**Charlotte**)
- Ohio (**Cleveland**)
- Oregon (**Portland**)
- Pennsylvania (**Philadelphia**)

- Puerto Rico (Isla de Vieques, San Juan)
- Rhode Island (Providence)
- Tennessee (**Memphis**)
- Texas (**Dallas-Ft. Worth, Houston**)
- Utah (Heber City, Richfield, **Salt Lake City**)
- Virginia (**Arlington, Dulles**)
- Washington (**Seattle**)
- Wyoming (Afton, Kemmerer, Ten Sleep)

The FAA has authorized more than 145 RNP procedures at 45 airports in 25 states, one U.S. territory, and one country.

RNP 2005 – March 2009 [Cities in **bold** have OEP airports]

- Alaska (Red Dog)
- Arizona (**Phoenix**, Tucson)
- California (Bishop, Burbank, Long Beach, **Los Angeles**, Ontario, Palm Springs, **San Francisco**, San Jose)
- Colorado (Hayden, Rifle)
- Ecuador (Quito)
- Florida (**Ft. Lauderdale, Miami, Tampa**)
- Georgia (**Atlanta**)
- Guam (Agana)
- Hawaii (**Honolulu**, Lihue)
- Idaho (Hailey)
- Illinois (**Chicago**)
- Indiana (Gary, Indianapolis)
- Kentucky (**Covington**, Louisville)
- Maryland (**Baltimore**)
- Minnesota (**Minneapolis-St. Paul**)
- Missouri (Kansas City)
- Nevada (Reno)
- New Hampshire (Manchester)
- New Jersey (**Newark**)
- New York (**New York**)
- Oklahoma (Oklahoma City)
- Oregon (**Portland**)
- Pennsylvania (**Pittsburgh**)
- Texas (**Dallas-Ft. Worth**)
- Virginia (**Arlington, Dulles**)
- Washington (**Seattle**)
- Wyoming (Jackson)

NextGen in Motion: Optimized Profile Descent (OPD)

As a component of its Trajectory-Based Operations (TBO) NextGen initiative, the FAA has authorized development of arrival procedures with vertical profiles optimized to facilitate a continuous descent from the top of descent to touchdown. OPD flight procedures use the capabilities of the aircraft Flight Management System to fly a continuous, descending path without level segments, based on the actual performance of the aircraft under current flight conditions.

Benefits

Benefits of these TBO initiatives, such as OPD, include fuel savings and noise and emissions reduction by keeping aircraft at higher altitude and at lower thrust levels than traditional step-down approaches. Simplifying routes using OPD also reduces radio transmissions between pilots and controllers.

OPD in Action

Two vertically-optimized arrival procedures were designed and successfully instituted at Los Angeles International Airport as part of the Southern California Redesign. Since 2004, OPD procedures have been evaluated extensively by United Parcel Service (UPS) at Louisville-Standiford International Airport, are being tested at Hartsfield-Jackson Atlanta International Airport, and were demonstrated at Miami International Airport in May 2008.

Los Angeles International Airport (LAX)

The new routes into LAX allow aircraft to glide down to the runway, using minimal power, starting approximately 70 miles east of the airport.

No special equipment is required to fly the new approach. On-board computers calculate an aircraft's best descent path into LAX based on the aircraft's performance abilities, weight, aircraft speed, and winds.

Other airports have limited OPD procedures in which aircraft can glide for portions of the approach before powering up for the final landing. So far, LAX is the only U.S. airport that has been able to accommodate a fully-optimized OPD in which aircraft can glide all the way into the airport from miles away. Two additional procedures were implemented at LAX in September 2008.

International Advances

In May 2008, the Atlantic Interoperability Initiative to Reduce Emissions (AIRE) partnership, including the FAA, Nav Portugal, Air Europa, and European Commission, conducted demonstrations to help reduce aviation's carbon footprint and reduce fuel consumption by manually optimizing flight trajectories across the Atlantic.

A total of eight Air Europa flights were flown with optimized trajectories from Madrid to the Caribbean through oceanic airspace controlled by Santa Maria, Portugal, and the New York Air Route Traffic Control Center. Flight dispatch at Air Europa recalculated trajectories in light of each flight’s current environment, winds, and the company’s cost index.

AIRE demonstrations are ongoing in 2009, and the plan is to include more flights, using a greater number of cities, and introduce eastbound trans-Atlantic flights. Oceanic trajectories eventually will bring together all stages of flight.

Looking to the Future

Performance-Based Navigation is a cornerstone of the FAA’s NextGen vision. As RNAV and RNP procedures are implemented in the NAS, they may provide additional end-to-end benefits by enabling a network of procedures at and between busy airports that will continue to enhance safety and capacity for industry and the flying public.