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Space Communication and Aviation Navigation: The United States Moves towards Performance-Based Navigation

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Highways in the Sky Video

Abstract

The U.S. NAVSTAR GPS communications satellite network, integrated with the FAA's Wide Area Augmentation System, or WAAS, provides improvements in GPS accuracy and integrity for aviation navigation throughout the U.S. National Airspace System. WAAS has allowed the FAA to move toward a performance-based NAS, exploiting the concept of "required navigation performance," or RNP. The FAA, in cooperation with aviation stakeholders, is implementing performance-based navigation in the U.S. NAS. Two key components of performance-based navigation are Area Navigation (RNAV) and RNP. These components allow the flexibility to design more efficient airspace and instrument procedures that improve safety, access, capacity and efficiency.

Foreword

The U.S. NAVSTAR Global Positioning System is comprised of 24 satellites in low earth orbit. They are communications satellites in the sense that they provide a digital data source to GPS users, which can then be translated into position, velocity, and timing.

The GPS Standard Positioning Service offers a highly accurate navigation solution for aviation users, but typically has an error of around 30 meters. While this is acceptable for many applications, the Federal Aviation Administration (FAA) realized that improvements in accuracy and integrity could yield a far more capable system that would allow the replacement of many of today's ground-based navigation aids (navaids). Thus came the GPS Wide Area Augmentation System, or WAAS.

WAAS uses a network of ground stations that measure the GPS error. WAAS ground stations send the error information to the WAAS Master Station which develops a correction message for broadcast through two geostationary communication satellites to GPS WAAS receivers. WAAS users can expect position accuracy of about two meters. With this level of accuracy, the FAA can use the WAAS signal to provide aviation navigation for all phases of flight throughout the U.S. National Airspace System (NAS), including instrument approaches with vertical guidance at airports throughout the NAS.

GPS WAAS has been the genesis of a major redesign of the entire national airspace system. The accuracy of ground-based navigation transmitters degraded with distance from the navaid. Using WAAS, a satellite-based system, the navigation accuracy is constant, whether en route or at the airport. This has allowed the FAA to move toward a performance-based NAS, exploiting the concept of "required navigation performance," or RNP. Since the aircraft have a more accurate navigation capability, airways can be spaced closer together. The use of RNP will help alleviate some current air traffic management issues and will help provide increases in capacity for the next 20 years. The integration of WAAS into the U.S. NAS will increase safety and capacity while providing substantial cost savings to both the FAA and the user community.

Performance-Based Navigation

The FAA, in cooperation with aviation stakeholders, is implementing performance-based navigation in the U.S. National Airspace System (NAS). Two key components of performance-based navigation are Area Navigation (RNAV) and Required Navigation Performance (RNP). Each includes lateral navigation standards for performance, functionality, and capability. These standards allow the flexibility to design more efficient airspace and instrument procedures that collectively improve safety, access, capacity and efficiency, and minimize environmental impacts.

RNAV is a method of navigation that enables aircraft to fly on any desired flight path within the coverage of referenced navaids, within the limits of self-contained systems, or a combination of these capabilities. The safety of an RNAV route or procedure is achieved through a combined use of aircraft navigation accuracy; air traffic radar monitoring and communications; and route separation.

RNP uses RNAV for navigation, with the addition of on-board navigation containment monitoring and pilot alerting when the required performance level in not sufficient for the route or procedure flown. This on-board performance monitoring and alerting reduces reliance on air traffic control intervention and pilot/controller communications, providing safety benefits and allowing more efficient procedure and route design.

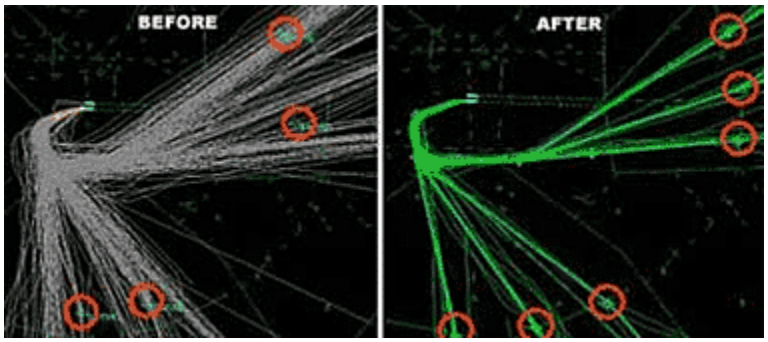
The FAA Roadmap for Performance-Based Navigation describes RNAV and RNP concepts and operational goals for the en route, arrival/departure, and approach phases of flight for the near term through 2006, mid term through 2012, and the far term through 2020. Approximately 90% of the U.S. air carrier fleet is RNAV capable and about 30% is RNP capable. As these numbers increase, the Roadmap provides a strategy to leverage advances in communication, navigation, and surveillance to derive benefits in capacity, efficiency, and environmental goals.

Performance-based navigation resulted in development of RNAV "Q" routes in the en route environment. The routes, designed for use above flight level (FL) 180, can be flown using GPS or DME/DME/IRU. Q-routes require navigation track keeping accuracy of ±2 nautical miles. Twenty routes have been published and 23 more are under development. Q-routes provide capacity and efficiency gains by allowing qualified traffic to be taken off crowded conventional routes.

Below FL180 (18,000 feet), RNAV IFR Terminal Transition Routes (RITTRs), called "T" routes, allow improved access to Class B and Class C airspace for GPS-equipped general aviation aircraft. The T-routes segregate aircraft transiting airspace from arrivals/departures at the primary airport. The first T-routes were charted in the Charlotte, NC, in September 2005. Additional routes are under development for Cincinnati, OH, and Jacksonville, FL. Terminal RNAV development includes Standard Instrument Departures (SIDs) and Standard Terminal Arrival Routes (STARs). The FAA published 36 RNAV SIDs and 16 RNAV STARs in FY 2005, including 13 SIDs at Atlanta, GA, and 16 SIDs at Dallas-Ft. Worth, TX.

Immediate, tangible benefits have been noted. Controller/pilot transmissions are reduced over 30 percent, there is a significant reduction in track dispersion, and the more efficient procedure designs reduce flight distances resulting in fuel savings for the airlines.

RNAV approach procedures have been used since 1969. One Roadmap focus is on the benefits to be gained from RNP applications in the approach arena. The FAA, in concert with the joint FAA/industry Performance Based Operations Aviation Rulemaking Committee (PARC), has developed design criteria, aircraft and operator requirements for RNP approaches with values ranging from RNP 0.3 to RNP 0.1 - i.e., three-tenths to one-tenth of a nautical mile navigation accuracy. A variety of aircraft system capabilities are employed to achieve lower minima while maintaining safety.



Hartsfield-Jackson Atlanta International Airport RNAV Standard Instrument Departures

A category of RNP approach procedure, the "Special Aircraft and Aircrew Authorization Required", or RNP SAAAR, may be developed by individual airlines and approved by the FAA to take advantage of specific equipment configurations, aircrew qualifications and operating procedures. RNP SAAAR

procedures are in development with airlines at Palm Springs, CA; Portland OR; Houston, TX; and New York, NY airports.

The FAA has refined SAAAR approach procedure criteria and recently published public-use RNP SAAAR criteria. The associated operator approval and aircraft performance requirements are also ready for publication. The first public RNP SAAAR approach was published for Reagan Washington National (DCA) in September 2005, and Alaska Airlines is expected to be the first carrier approved for the new procedure. Production of RNP SAAAR procedures for other locations will begin in October 2005.

Performance-based navigation made significant advances in NAS operations in FY 2005, and FY 2006 promises to be even more dynamic. The combined FAA and aviation stakeholder partnership will continue development of RNAV/RNP en route, arrival/departure and approach routes and procedures, and will jointly pursue the communication, navigation and surveillance advances projected in the Roadmap for Performance-Based Navigation.