NextGen for Airports, Volume 1: Understanding the Airport’s Role in Performance-Based Navigation: Resource Guide

DETAILS
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Among the key factors impacting the utilization of PBN procedures are (1) the FAA’s NextGen Implementation Plan for implementing or leveraging PBN and other relevant NextGen capabilities and 2) the ability of aircraft to utilize the PBN procedures.

**FAA Implementation Plans**

The FAA’s plans for implementing PBN procedures and other relevant NextGen capabilities are included in the FAA’s NextGen Implementation Plan. These plans and other relevant NextGen capabilities are presented in Table 3-1 according to their estimated time frame for implementation (near-, mid- and long-term), similar to the time frames for airport master planning.

The FAA’s near-term focus for PBN is the design and implementation of PBN procedures at airports across the U.S. Other capabilities relevant to PBN include utilization of data communications (Data Comm) to issue pre-departure clearances to aircraft, and deploying ground-based augmentation system (GBAS) at airports in order to support CAT I precision approaches. The FAA near-term PBN procedures and their associated NextGen capabilities are presented in Table 3-1.

Table 3-1. The FAA near-term PBN and NextGen implementation plans.

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<tr>
<th>TIME FRAME</th>
<th>FAA PBN</th>
<th>FAA NEXTGEN</th>
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<tbody>
<tr>
<td>Near Term (0–5 Years)</td>
<td>In the en route/terminal airspace: Area navigation (RNAV) 2 Q-routes RNAV 2 T-routes</td>
<td>Data Comm: Air traffic control (ATC) to issue pre-departure clearances and revised clearances to flights</td>
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<td>Automatic dependent surveillance-broadcast (ADS-B) out of aircraft position is mandatory for aircraft on January 1, 2020</td>
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</table>
In the terminal airspace:
- RNAV 1 standard terminal arrival routes (STARs) with or without optimized profile descents (OPDs)
- RNAV 1 standard instrument departures (SIDs) with or without unrestricted climbs
- Required navigation performance (RNP) 1 STARs and SIDs with or without radius-to-fix (RF) legs
- RNAV standard instrument approach procedures (SIAPs) including lateral navigation (LNAV), LNAV with vertical navigation (LNAV/VNAV), localizer performance (LP), LP with vertical guidance (LPV), RNP 0.3 and RNP approval required (AR)

FAA optimization of airspace & procedures in the metroplex (OAPM), currently metroplex controller-pilot data link communications (CPDLC)

Ground-based augmentation system (GBAS) precision approaches equivalent to instrument landing system (ILS) category (CAT) I precision approaches

Note: FAA is participating in, but does not fund, GBAS installations providing CAT I precision approach services (Federal Aviation Administration 2016a).

Table 3-2. FAA mid- and far-term PBN and NextGen implementation plans.

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<tr>
<th>TIME FRAME</th>
<th>FAA PBN</th>
<th>FAA NEXTGEN</th>
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| Mid Term (5–10 years) | Concept of operations, requirements, criteria, rules and regulations to address mixed aircraft navigation equipage and capabilities | Data Comm for air traffic control (ATC) to issue airborne clearances for in-flight route negotiation between ATC and the flight crew
Ground based augmentation system (GBAS) to support precision approaches equivalent to instrument landing system (ILS) Cat II/III approaches
Automatic dependent surveillance-broadcast (ADS-B) Out for ATC separation and advisory services |
Table 3-2. Continued

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<th>TIME FRAME</th>
<th>FAA PBN</th>
<th>FAA NEXTGEN</th>
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<tr>
<td>Long Term</td>
<td>Implementation of policies and operations to address mixed aircraft</td>
<td>Data Comm and ADS-B In for flight information services-broadcast (FIS-B),</td>
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<td>(10–20 years)</td>
<td>navigation equipage and capabilities</td>
<td>traffic information services broadcast (TIS-B), cockpit display of traffic</td>
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<td></td>
<td>Advanced required navigation performance (RNP) standard terminal</td>
<td>information (CDTI) and alerting, interval management (IM), advanced flight-</td>
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<td>arrival routes (STARs), standard instrument departures (SIDs) and</td>
<td>deck IM (FIM), closely spaced parallel runway operations (CSPRO), and in-</td>
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<td></td>
<td>standard instrument approach procedures (SIAPs) combining NextGen</td>
<td>trail procedures (ITP)</td>
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<td>technologies to enable integrated operations</td>
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<td></td>
<td>Scalable RNP</td>
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<td>RNP Holding</td>
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<td>Required time of arrival (RTA) navigation capability of aircraft to</td>
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<td></td>
<td>meet a scheduled time at a waypoint</td>
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<td>Air traffic control ability to assign and aircraft ability to fly</td>
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<td>dynamic RNP routes</td>
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<td></td>
<td>PBN for unmanned aerial vehicle (UAV) operations</td>
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¹Note: The FAA NextGen Implementation Plan includes standards validation and federal approval development for GBAS installations providing CAT II/III precision approach services (Federal Aviation Administration 2016a).

PBN implementation in the midterm may focus on developing a concept of operations for planning and managing aircraft of different capabilities including aircraft type, levels of navigation capability, and flight performance. One example is the FAA’s best-equipped best-served concept of operations proposed to address mixed equipage (Federal Aviation Administration 2012b). Procedures for managing mixed equipage traffic are not explicitly included in the FAA’s NextGen Implementation Plan; instead, they fall under the FAA’s NextGen Portfolio of Separation Management. The aim of Separation Management is to develop air traffic control tools and procedures to separate aircraft that have different kinds of navigation equipment and wake performance capabilities.

PBN implementation in the long term includes: leveraging the required time of arrival (RTAr) capability of aircraft to meet scheduled times to navigation waypoints; the integration of PBN procedures with other NextGen technologies and capabilities to enhance their collective benefits; the utilization of dynamic PBN routes to support the strategic and tactical management of air traffic; and PBN for UAV operations.

NextGen capabilities relevant to PBN in the mid term include a number of enabling technologies. Data link communications will allow air traffic control (ATC) to negotiate reroutes with the flight deck and to issue clearances to aircraft while airborne. Development of GBAS will enable Cat II and III preci-
sion approaches at airports. Automatic dependent surveillance-broadcast (ADS-B) Out from aircraft will increase position accuracy, expand surveillance coverage, and enable ATC to provide enhanced separation and advisory services in remote areas not covered today. Other NextGen capabilities in the mid-term time frame relevant to PBN include the use of ADS-B In to aircraft to support a broad range of capabilities (Informal Pacific Air Traffic Control Coordinating Group 2013). These include:

- Traffic information services-broadcast (TIS-B) to broadcast the positions of air traffic in areas where not all aircraft have ADS-B for presentation on aircraft cockpit displays and alerting to pilots;
- Flight information services—broadcast (FIS-B) to provide meteorological and aeronautical information such as weather images, weather forecasts, airspace restrictions, and notices to airmen;
- Cockpit display of traffic information (CDTI) to present on aircraft cockpit displays the positions of air traffic in the area, possibly with on-board alerting of conflicting traffic for non-traffic collision avoidance system (TCAS) aircraft;
- Interval management (IM) to manage in-trail spacing of aircraft in all flight phases, including ground-based interval management—spacing (GIM-S) and flight deck based interval management—spacing (FIM-S) applications;
- Applications to closely spaced parallel runway operations (CSPRO) at airports, for instance, enhanced visual approaches using CDTI; and
- In trail procedures (ITP) in oceanic airspace.

**Equipage Levels of Aircraft at Airports**

The implementation of particular PBN procedures at an airport, and the utilization of those PBN procedures, depends on the navigation capabilities of aircraft among the fleet the airport serves and on aircraft operator policy regarding the use of PBN procedures. Figure 3-1 depicts the current equipage levels among air transport operators [14 Code of Federal Regulations (CFR) Part 121 operators] and air taxi operators (14 CFR Part 91K and 135 operators) as determined by the FAA (Federal Aviation Administration 2016b).

Figure 3-1 indicates that almost 100 percent of commercial air carrier operators are equipped to perform RNAV 1, RNAV 2, RNP 1, and RNP 2 PBN procedures and approximately 50 percent of air transport aircraft and almost no air taxi aircraft are equipped to perform RNP 1 with curved paths or RNP AR Approaches.

Figure 3-2 depicts the historical and forecast PBN capabilities of the aircraft operating under instrument flight rules (IFRs) at the top 50 airports in the U.S. (The MITRE Corporation 2011). The results are based on analysis of the fleets of aircraft filed to fly to and from the top 50 airports in the U.S.

Figure 3-2 indicates that only 60 percent of commercial air carriers will be equipped and approved to conduct RNP AR procedures by 2024. This data indicate a potential high level of future participation on oceanic, en route, SID, and STAR procedures, but a lower participation on SIAPs.

In addition, stakeholder outreach was conducted to gain insight into the intentions of aircraft operators to equip their aircraft for PBN procedures and to implement policies encouraging the use of PBN procedures. Regarding levels of PBN capability among aircraft operators, survey respondents indicated their fleets were 100 percent equipped for GPS navigation and RNAV procedures in the en route and terminal airspace domains, and many were certified for RNP procedures. Few were equipped for LPV approaches, although equipage for and utilization of LPV approaches was expected in the future. RNP
AR procedures were a significant differentiator among aircraft operators due to their aircraft equipage and crew training requirements. While some carriers have fleets entirely equipped for and regularly use RNP AR procedures, others were not equipped for them and had no plans to equip for them in the near future. Regarding wide area augmentation system (WAAS), some operators reported WAAS capabilities of their fleet or were planning future installation and use of WAAS, while others had no intention of WAAS utilization. Regarding GBAS, there was support indicated from the major carriers, with some exploring GBAS, while others stated there was not a business case for it. Regarding ADS-B, all operators surveyed planned to be equipped for it to meet the 2020 mandate. Some were already using ADS-B Out to communicate aircraft state information, and some had plans to use ADS-B In for weather data from a third-party vendor. Many aircraft operators have policies that encourage the use of PBN procedures, some have standard operating procedures to use PBN procedures, and one even requires using PBN procedures. However, in many cases, the use of PBN procedures was subject to pilot discretion and usage among them varied from 85 to 100 percent. Most operators surveyed are flying RNAV SIDs, RNAV STARs with OPDs and RNAV approaches as often as possible.

Figure 3-1. Current navigation capabilities among air transport and air taxi operators.
Mixed Equipage of Aircraft at Airports

As indicated in Figure 3-1 and Figure 3-2, equipage levels among aircraft vary and will continue to vary for the foreseeable future. The varying capabilities of aircraft operating in the NAS are referred to as “mixed equipage.” Mixed equipage presents a barrier for the realization of full NextGen capability and benefits throughout the NAS. A mixed equipage environment will have an increased level of traffic complexity and higher controller workload and may preclude advanced operations during peak traffic conditions.

Today, air traffic services are provided on a first come, first served basis. The aviation industry is promoting policies for PBN-equipped aircraft to be given priority over non-equipped aircraft. Such policies would benefit aircraft operators who have invested in PBN avionics and would promote increasing equipage levels by encouraging the other operators to invest.

FAA has held industry meetings to discuss such policies and, despite the issues with mixed equipage, has stated that they are working toward infrastructure and operational changes that will gradually accommodate such policies. The desire is to allow PBN operations while also accommodating legacy operations. Among the areas being looked into are:

- Traffic management based on predicted and actual four-dimensional trajectories of aircraft (latitude, longitude, altitude, and time);
- Simultaneous dependent approaches to closely spaced parallel runways;

Source: The MITRE Corporation 2011.

Figure 3-2. Forecast navigation capabilities among aircraft at top 50 U.S. airports.
• Using CDTI enabled by ADS-B to allow visual separation in IFR conditions;
• Using collision risk management criteria to determine separation standards;
• Using digital air/ground communications to achieve more efficient traffic flow; and,
• Achieving efficiencies through development and application of systemwide information management.

In addition to strategies for managing mixed equipage, utilization of PBN procedures also depends on the tactical management of mixed equipage traffic. This requires improved controller tools and operations to manage traffic using PBN procedures without vectoring aircraft. To manage traffic without vectoring, controllers need traffic planning and control tools as well as associated operating procedures for metering, sequencing, spacing, and separation assurance. Research efforts including the NASA terminal sequencing and spacing (TSS) (Swenson et al. 2011) and the MITRE relative position indicator (RPI) (The MITRE Corporation 2012) are steps towards this. However these efforts and previous ones have not borne the necessary operational changes (Poole 2013).

Mixed equipage will have ground-side impacts on the airport. As the efficiencies of air-side operations increase, resultant throughput increases may require changes to how ground-side processes, from ramp and gate management to passenger accommodations, are implemented. This is a long-term process; nevertheless, airport management should be aware of the possible impacts of FAA NextGen PBN changes and how they can influence those impacts.