Performance-Based Navigation: A Pilot's Guide

Performance-Based Navigation (PBN) is transforming the way we navigate in the skies. It relies on the accuracy, integrity, availability, and continuity of navigation systems instead of the physical placement of ground-based navigational aids. For instrument-rated pilots, understanding PBN concepts, particularly RNAV and RNP designations, is crucial to using modern navigation systems like the Garmin GTN and G1000 navigators. This article breaks down the key elements of PBN and includes a closer look at Satellite-Based Augmentation Systems (SBAS), RAIM functionality, and why these concepts matter in everyday flying.

What is Performance-Based Navigation (PBN)?

PBN encompasses area navigation (RNAV) and required navigation performance (RNP). Both RNAV and RNP allow pilots to navigate using waypoints defined by latitude and longitude rather than traditional VORs. PBN is classified by navigation accuracy, and specific performance requirements are designated for each phase of flight, including en-route, terminal, approach, missed approach, and departure procedures (DPs) and standard terminal arrival procedures (STARs).

PBN uses RNAV and RNP specifications that outline a certain level of accuracy defined in nautical miles. These designations ensure safe navigation across all flight environments.

SBAS: Enhancing Navigation Precision

SBAS (Satellite-Based Augmentation System) enhances GPS signals by providing corrections for satellite position errors, atmospheric conditions, and clock errors. For pilots using systems like the Garmin GTN or G1000, SBAS enables high-accuracy navigation and access to LPV (Localizer Performance with Vertical Guidance) approaches, offering near-ILS precision without the need for ground-based equipment.

Currently there are 9 SBAS augmentation systems around the world – WAAS in the U.S., EGNOS in Europe, MSAS in Japan etc. not to be confused with Global Navigation Satellite Systems (GNSS) such as GPS in the U.S., Galileo in Europe, and Glonass in Russia. The WAAS system (Wide Area Augmentation System) in the U.S., are crucial for enabling vertical guidance and ensuring integrity monitoring, essential for modern RNP approaches. Without SBAS, many precision approaches would be unavailable to GA pilots.

RAIM: Ensuring Navigation Integrity

Receiver Autonomous Integrity Monitoring (RAIM) is a critical feature of GPS navigation systems. It continuously monitors satellite signals to ensure the required accuracy and integrity for navigation. If RAIM detects insufficient satellites or faulty signals, it alerts the pilot to avoid relying on the GPS data.

- **G1000 Systems:** RAIM operates seamlessly in the background of G1000 systems, constantly ensuring navigation integrity. With integrated SBAS, these systems also enable advanced approach capabilities, such as LPV minimums.
- **GNS 430 Systems:** Unlike the G1000 and GTN systems, the GNS system relies on simpler RAIM functionality without SBAS integration. It also lacks RNP 1 or RNP .3 limiting the system's capability to fly RF approaches or approaches requiring vertical guidance, such as LPV.

Understanding RAIM and SBAS is essential for pilots to ensure their equipment is capable of meeting the requirements of their planned operations.

Key PBN Designations: RNAV vs. RNP

Within the PBN framework, RNAV and RNP specifications define the accuracy and capability requirements of navigation. While these terms are often used interchangeably, they have distinct differences and applications.

1. RNAV (Area Navigation)

RNAV enables an aircraft to fly any desired flight path within the coverage of satellite-based navigation. The primary characteristic of RNAV is its flexibility in creating direct paths between waypoints, reducing flight distances and fuel consumption. However, RNAV does not include specific onboard performance monitoring and alerting capabilities that enhance safety by warning pilots if system integrity is degraded. That's what RNP provides.

Common RNAV Designations:

- **RNAV 10:** Used in oceanic and remote areas, allowing an accuracy of 10 NM.
- **RNAV 5:** Permits a 5 NM lateral navigation accuracy, commonly used in en-route operations.
- **RNAV 2:** Meets 2 NM lateral accuracy 95% of the time, typically applied to en-route operations.
- **RNAV 1:** Meets 1 NM lateral accuracy, used for SIDS and STARs in terminal airspace.

Typical GA navigators, such as the Garmin GTN and G1000, provide RNAV 1 and RNAV 2 capability.

2. RNP (Required Navigation Performance)

RNP is a subset of RNAV that includes onboard performance monitoring and alerting. This onboard monitoring, supported by RAIM and, in modern systems, SBAS, enables the aircraft to identify when navigation integrity deviates from the required performance standard and alerts the pilot. This makes RNP necessary for precision and non-precision approaches, missed approaches, and terminal procedures where navigation accuracy is essential for safety.

Common RNP Designations:

- **RNP 4:** Used in oceanic and remote areas, where the system must maintain ±4 NM lateral accuracy.
- **RNP 2:** Designed for en-route area navigation with ±2 NM lateral accuracy.
- **RNP 1:** Designed for terminal area navigation with a lateral accuracy of ±1 NM.
- **RNP APCH:** Includes straight-in and curved Radius-to-Fix (RF) approaches, allowing LP, LNAV, and LPV minimums, with typical .3 accuracy before the FAF and .1 accuracy under most conditions on the final approach segment.
- **RNP AR (Authorization Required):** These approaches are highly specialized, with tight radius-to-fix (RF) turns and narrow navigation tolerances. Most GA aircraft will not have these procedures available in their database.

Typical GA navigators, such as the Garmin GTN and G1000, provide RNP 2, RNP 1, and RNP APCH capability.

Why Should You Care?

Understanding SBAS and RAIM is more than a theoretical exercise; it directly impacts your daily flying. Here's why:

1. **Access to More Approaches:** With SBAS, your navigator can handle precision approaches like LPV, opening up access to airports without ILS equipment.
2. **Increased Safety:** RAIM ensures that the navigation data you rely on is accurate, reducing the risk of errors during critical phases of flight.
3. **Regulatory Compliance:** Many procedures, including RNP 1 and RNP APCH, are becoming standard for terminal and approach operations. Equipping yourself with knowledge and understanding of these systems ensures compliance with modern airspace requirements.

ICAO and PBN codes vary depending on whether DME is included in your avionics, but for most non legacy Cirrus aircraft (G3 Perspective, G5, G6, and G7 models) without DME appropriate ICAO Equipment Codes are as follows: If you have DME equipment, D should be added to your equipment code.

B (LPV)

G (GNSS)

R (PBN Approved)

S (VOR, ILS)

Y (VHF 8.33 spacing)

ICAO Equipment	B, G, R, S, Y
ICAO Surveillance	B1, C
ICAO Wake Category	L
ICAO PBN	D2, O2, S1

ICAO PBN Codes are:

D2 (RNAV 1 using GNSS)

O2 (RNP 1)

S1 (RNP APCH)

In summary, pilots using advanced systems like the Garmin GTN or G1000 with SBAS, RAIM, PBN, and RNP will be able to enhance operational flexibility, safety, and efficiency. Performance-Based Navigation is not just the future; it's the present. Mastering the fundamentals of PBN, ensures you can take full advantage of the capabilities of your modern avionics. From RNAV 1 departures to RNP APCH procedures, understanding these systems elevates both your confidence and competence in the cockpit.

The following flowchart may be useful to understand the relationships, capabilities, and limitations of RNAV and RNP within the PBN architecture.