Performance-Based Navigation

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. Let's break down the key elements of PBN and demystify the various RNAV and RNP designations.

What is Performance-Based Navigation (PBN)?

PBN is a concept that 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, as well 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 are established to ensure safe navigation in all flight environments.

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 that are important to understand.

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 alerting pilots if system integrity is degraded. That's what RNP provides.

   Common RNAV Designations:

   - **RNAV 10**: Used primarily 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 enroute operations.
   - **RNAV 1**: Meets 1 NM lateral accuracy, used for SIDS, STARS in terminal airspace.

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

2. **RNP (Required Navigation Performance)**
   RNP is a subset of RNAV that includes onboard performance monitoring and alerting, adding a layer of safety and reliability. This onboard monitoring known as Receiver Autonomous Integrity Monitoring (RAIM) 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 departure and arrival procedures where navigation accuracy is essential for safety.

Common RNP Designations:

- **RNP 4**: Used in oceanic and remote areas, where the system must be able to maintain a lateral accuracy of $\pm$4 NM.
- **RNP 2**: Designed for en-route area navigation with $\pm$2 NM lateral accuracy.
- **RNP 1**: Designed for terminal area navigation with a lateral accuracy of $\pm$1 NM.
- **RNP APCH**: A designation for approach procedures that includes both straight-in and may include curved Radius to Fix (RF) approaches. RNP APCH procedures are flown to LNAV or LP minimums to an MDA (with or without advisory vertical guidance) as well as LPV minimums to a DA.
- **RNP AR (Authorization Required)**: These approaches are highly specialized, allowing for tight radius-to-fix (RF) turns, curved paths, and descent gradients in challenging environments. Pilots and operators need specific authorization due to the stringent monitoring requirements and narrow navigation tolerances. Most GA aircraft will not find these approaches available in their GPS database.

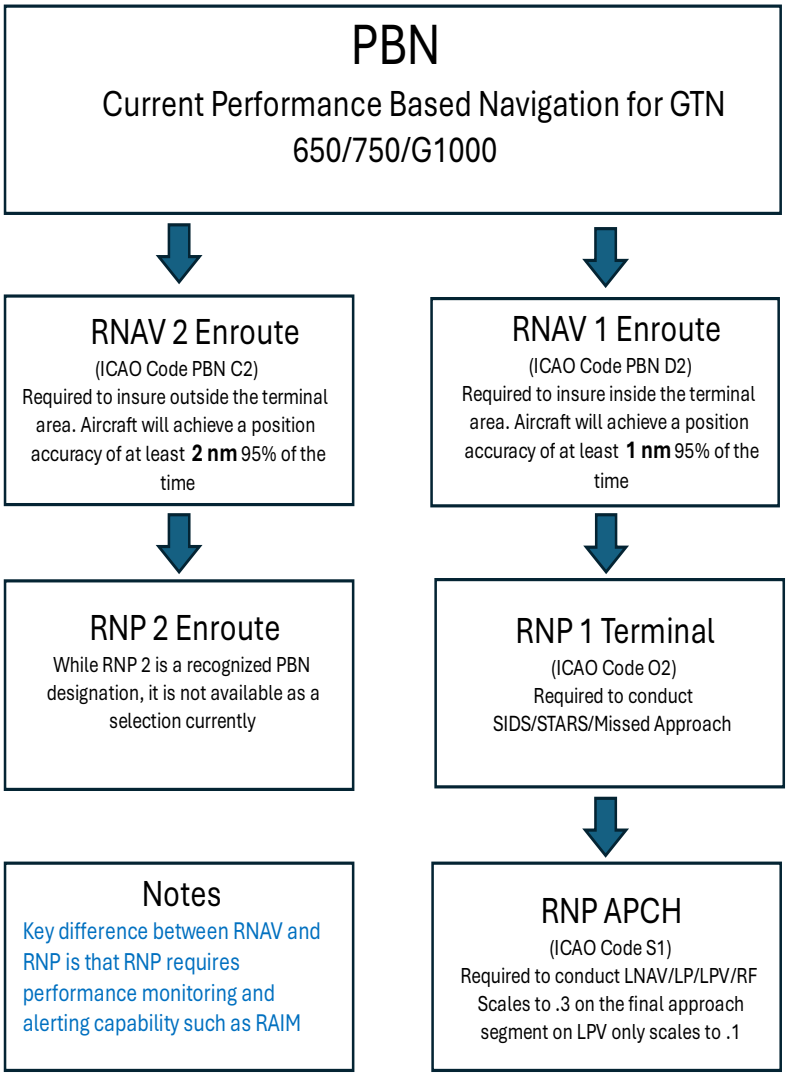
  Typical GA navigators such as the Garmin GTN and G1000 provide RNP 2, RNP 1, and RNP APCH capability.

Note: Garmin GTN and G1000 navigators, for instance, are capable of conducting RF and RNP 1 approaches, making it suitable for navigating complex approaches that require high precision and flexibility.

Key Differences Between RNAV and RNP

Aspect	**RNAV**	**RNP**
Onboard Performance Monitoring	No	Yes
Alerting Capabilities	No	Yes
Precision	High accuracy but no performance monitoring	High accuracy with performance monitoring
Use for Approaches	Limited	Widely used, especially RNP APCH
Typical Applications	General en-route, terminal, and some approach operations	Non precision and precision approaches and RF approaches

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


PBN
Current Performance Based Navigation for GTN 650/750/G1000
RNAV 2 Enroute
(ICAO Code PBN C2)
Required to insure outside the terminal area. Aircraft will achieve a position accuracy of at least 2 nm 95% of the time
RNAV 1 Enroute
(ICAO Code PBN D2)
Required to insure inside the terminal area. Aircraft will achieve a position accuracy of at least 1 nm 95% of the time
RNP 2 Enroute
While RNP 2 is a recognized PBN designation, it is not available as a selection currently
RNP 1 Terminal
(ICAO Code O2)
Required to conduct SIDS/STARS/Missed Approach
Notes
Key difference between RNAV and RNP is that RNP requires performance monitoring and alerting capability such as RAIM
RNP APCH
(ICAO Code S1)
Required to conduct LNAV/LP/LPV/RF
Scales to .3 on the final approach segment on LPV only scales to .1