Podcast 23 - PBN

Hi everyone and welcome back to the 737 Talk where this week Ian and I will be trying to shed some light on what can be quite a confusing topic. That is PBN or Performance Based Navigation. We'll look at What it is, how it affects our operations and where it is likely to be going in the future.

For those who want further reading we'll put links to some of the documents we used in writing this podcast over on our website www.b737talk.com

These ICAO documents include Doc 9613 – Performance-based Navigation (PBN) Manual Doc 9992 - Manual on the use of Performance-based Navigation (PBN) in Airspace Design and Doc 9997 – Performance-based Navigation (PBN) Operational Approval Manual. We'll also include a link to the FAA Advisory Circular 90-105A for our colleagues across the water.

So, what is PBN? Basically, it redefines the aircraft's required navigation capability from sensor equipment to being performance based. It was designed with an aim to increase capacity in already congested airspace taking advantage of technological advances. The Victor airways system for example in the United States required airways to be 8 miles wide and for crews to tune specific ground-based systems as they go. PBN offers the opportunity to narrow those airways and create lat long based waypoints through use of aircraft FMS thus increasing the density of routes potentially available.

The main benefits of PBN are the increase in capacity as just stated, the reduction in necessary infrastructure and thus environmental impact, and the improvements in operational efficiency and flight safety.

The foundation for Performance Based Navigation is area navigation or RNAV which is why we often see these two lumped together creating an element of confusion. This is being worked on but more on that later.

The RNAV method of navigation permits aircraft operation on any desired flight path within coverage of station-referenced navigation aids or within the limits of the capability of self-contained aids, or a combination.

Requirements for navigation applications on specific routes or within a specific airspace must be defined in a standard manner. This means flight crew and air traffic controllers are aware of the on-board RNAV or RNP system capabilities in order to determine whether the performance of the RNAV or RNP system is appropriate for the specific airspace requirements. As I'm sure you're all aware we have specific lateral containment values that the aircraft must be able to remain within, in order to be approved for operation in that airspace. For example, RNAV 1 is used for DPs and STARs and appears on the charts. Aircraft must maintain a total system error of not more than 1 NM for 95 percent of the total flight time in order to be approved for such procedures.

In the same sentence Ian just mentioned RNAV and RNP without batting an eye lid. Some clarification is needed on the difference between the two. Area navigation or RNAV and required navigation performance or RNP systems are fundamentally similar. The key difference between them is the requirement for on-board performance monitoring and alerting. RNP requires this on-board monitoring and alerting. We see this on the 737 via the FMS checking system accuracy and then warning us of any degradation through messages such as UNABLE REQD NAV PERF - RNP on the NAV display, FMC DISAGREE or VERIFY POSITION.

RNAV consists of RNAV 1, 2, 5 and 10 for different areas of operation with the most accurate being for the terminal environment and the least RNAV 10 being for Oceanic and remote navigation areas. RNP is made up of RNP 1, 2, 4 and 10 with approach categories of 0.3 and for RNP AR (Authorisation Required) down to as low as 0.1. The numerical value for both types here is the lateral navigation accuracy in nautical miles that the aircraft is expected to maintain within at least 95% of the time.

RNAV routes are designed to be twice the RNAV specification value from the route centreline, so in other words if you are on an RNAV 2 route the boundary will go out to 4 miles either side of the charted track centreline making the airway 8 miles wide.

The primary route width for RNP from the route centreline is the RNP value so an RNP 2 primary route boundary to boundary would be 4 miles wide. On an RNP 0.3 final approach segment the secondary area is also protected from obstacles making the protected distance 0.6 miles either side of the centreline or 1.2nm total width. The same theory applies in the final approach segment at RNP 0.1 on an RNP AR approach with the protected 0.1nm secondary area giving a total width here of 0.4nm. RNP 1 gets the same secondary area protection giving a total width here of 4 miles.

As a bit of extra knowledge, procedure design criteria specify an obstacle evaluation area of 2 x the RNP. For an approach, default obstacle evaluation criteria where no special authorisation is required, consists of RNP 1 for the initial and intermediate segments, RNP 0.3 for the Final approach segment and then RNP 1 again for the missed approach.

Let's have a look at how we as pilots interact with this system. We need to know what type of RNAV or RNP airspace we are operating in and whether or not the aircraft and us as crew are capable of regulation compliance.

Aircraft eligible for RNP operations will have an appropriate entry including special conditions and limitations in its AFM, avionics manual, or a supplement. Operators of aircraft not having specific RNP eligibility statements in the AFM or avionics documents may be issued operational approval including special conditions and limitations for specific RNP eligibilities. We as crew need to check before flight that the aircraft is able to fly any of the procedures we can perhaps expect. Hopefully our company is helpful by providing you with that information in an easily accessible way so just be sure to check you know where it can be found.

Before flight we must review maintenance logs and forms to ascertain the condition of the equipment required for flight in RNP airspace or on routes requiring RNP 4 navigation capability and ensure that maintenance action has been taken to correct defects in the required equipment; and we need to review the contingency procedures for operations in RNP airspace or on routes requiring an RNP 4 navigation capability. These are no different than normal oceanic contingency procedures with one exception: crews must be able to recognize, and ATC must be advised, when the aircraft is no longer able to navigate to its RNP 4 navigational capability.

At dispatch or during flight planning, the operator must ensure that adequate navigation capability is available enroute to enable the aircraft to navigate to the required RNP 4. We can check RAIM AUGUR from Eurocontrol or on the FAA website which we'll put links to over on our website www.b737talk.com. Please check your own authorities' websites if you are outside of these regions or perhaps your helpful company will provide you with links too. As a refresher RAIM, or Receiver Autonomous Integrity Monitoring, is the GNSS receiver's ability to perform Fault Detection or Fault Detection Exclusion dependent upon the number of satellites in view. The answer to that is that it must be a minimum of 5 for fault detection and 6 for fault detection and exclusion, or FDE. Once airborne we don't have to do an in-flight RAIM check and can rely on ANP after this point.

On the CDU we can look at our RNP against Actual or ANP, one place is progress page 4. The RNP will be from the database, and it is always worth checking that it is the correct RNP for the phase of flight, especially if on an RNP approach. Default values from the database tend to be RNP 1.0 for DPs and STARs, RNP 12 for oceanic and RNP 0.5 for approach if nothing else is coded in. Talking of that database it is also of prime importance to make sure you are operating from a current version when doing your pre-flight. ANP as implied is the current accuracy of the FMS position.

Flying a RNAV/RNP departure or arrival in the 737 involves the use of LNAV and VNAV after a careful check of your companies required equipment and aircraft and crew authorisation. You will need to do a check of your company SOPs in regard to how the route is entered, any allowable changes or corrections such as cold weather adjustments as well as a thought to contingency planning if you were to lose the required navigation capability.

Similar procedures will need to be followed for the approach itself, but these are very company specific, so we suggest having a good read of your company manuals for this. They will include things such as an equipment check, tracks and distance check, possible cold weather corrections, deviation monitoring and contingency procedures. Remember as well here to check the charted temperature minimums and maximums for the approach as you will not be able to use VNAV below or above these.

On some approaches you will see LPV minimums. LPV stands for Localiser Performance with Vertical Guidance (**LPV**) and is defined as an Approach with Vertical Guidance (APV); that is, an instrument approach based on a navigation system that is not required to meet the precision approach standards of ICAO Annex 10 but that provides both course and glidepath deviation information. It is not authorised unless the aircraft is equipped with Wide Area Augmentation System AND the operator is approved to use it.

So, to us as pilots. Licensing requirements were introduced with Regulation (EU) 2016/539. These meant that as of 25 August 2020 PBN privileges shall be required for every IR. This licence endorsement is granted after the pilot has successfully completed a course of theoretical knowledge including PBN, the pilot has successfully completed flying training including PBN and has also successfully completed either a skill test or a proficiency check. Please look into your own regulatory authority for requirements in your part of the world.

Let's now have a look at the most advanced type of PBN and what we can expect from the system going forward.

RNP AR approaches or Authorisation Required have stringent equipment and pilot training standards and require special over site authority authorization to fly. Scalability and RF turn capabilities are mandatory in RNP AR APCH eligibility. RF means Radius to Fix, these turning parts provide flexibility in design and can be included in all phases of the procedure including the final segment and will involve a speed restriction. RNP AR APCH vertical navigation performance is based upon barometric VNAV or SBAS. RNP AR is intended to provide specific benefits at specific locations where a regular approach is perhaps impossible to design down to the minima required for commercial operations. It is not intended for every operator or aircraft. RNP AR capability requires specific aircraft performance, design, operational processes and crew training, as well as special procedure design criteria to achieve the required level of safety. RNP AR APCH has RNP values that can range from 1nm to 0.1nm in the approach and missed approach segments.

You may need specific operator approval for each RNP AR approach as well as a general AR approval and we as pilots need to be trained to standard on the technicalities, the procedures and the contingencies involved in flying these highly accurate approaches. At the point of writing this podcast the 737 Max was temporarily banned from these approaches, but we are expecting it to be approved eventually.

To monitor these approaches on the 737 we have NPS scales and ANP in both the vertical and horizontal plane. Aircraft without NPS scales are not authorised for RNP AR. As well as on the CDU these RNP/ANP scales will show on the ND giving us good situational awareness tools. We are alerted to the limits being reached by the associated scales or indications turning Amber as well as the message UNABLE REQD NAV PERF RNP on the ND. Other messages that will require intervention during the approach are FMC DISAGREE or VERIFY POSITION. Just a side note here. If you had to change the RNP in the CDU to a manually entered value, just remember that you'll have to delete it if necessary for continued flight.

Going forward we are looking at an ECAC (European Civil Aviation Conference) wide roll out or Advanced RNP or A RNP which is for navigation in all phases of flight. At the time of writing the detail of the regulatory guidance was still under development but coming soon. A-RNP should start to clear up all the confusion of different names for what can be very similar procedures tidying up B-RNAV, P-RNAV, and the various RNP APP acronyms into one simple format. RNP values are likely to be uniform at 1nm across all areas with 0.3nm for final approach. RNP AR will then provide the specific lower values needed where needed.

A-RNP will further increase capacity and efficiency through route design and improved capability for continuous climb or descent operations. The good news for operators is that A-RNP doesn't require any more equipment or crew training than current RNP does.

The other good news comes in the naming of charts as we continue to untangle the web that often comes with new technology bolt ons. From 1 December 2022, only the term RNP will be permitted, so RNP RWY XX or RNP RWY XX (AR) will be acceptable while RNAV, GPS and GNSS will not be. During the transition period however, it is possible to have a considerable variation in the IAP designation policies of different countries.

That's it! I hope that has cleared up a few of the meanings and terms that come in to PBN and given you hope that this will be more straight forward in regard to the future. There is a lot of in-depth reading that can be done around this subject, and we have a number of useful links on the Talk website if you want more. Please remember that in regard to flying these approach procedures your company will have specific requirements that must be adhered too and will hopefully be set out in a clear manner for you including contingency procedures, especially when it comes to RNP AR approaches in mountainous areas. We'll look forward to bringing you another podcast soon but for now why not head over to our social media pages to continue the talk with peers as I'm sure this subject has a number of questions attached to it. Until next time from Mark and I fly well and be safe.