AIRBUS

HELICOPTERS

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SAFETY PROMOTION NOTICE

SUBJECT: AUTO FLIGHT

Benefits & implementation of Point in Space procedures

For the attention of

AIRCRAFT CONCERNED	Version(s)	
	Civil	Military
AS365	N, N1, N2, N3	F, Fs, Fi, K, K2
AS565		MA, MB, SA, SB, UB, MBe
SA366		GA
EC155	B, B1	
EC225	LP	
EC725		AP
AS332	C, C1, L, L1, L2	B, B1, F1, M, M1
AS532		A2, U2, AC, AL, SC, UE, UL
EC175	B	
H160	B	
MBB-BK117	C-2, C-2e, D-2, D-3	D-2m, D-3m
EC135	T3, P3, EC635 T3, T3H, P3H, EC635 T3H	

Foreword

The purpose of this document is to provide the Operators of Airbus aircraft/helicopters with the manufacturer's perspective of the applicable Performance-Based Navigation (PBN) regulations. This document has therefore been written to help Operators understand the following aspects:

- Frequently Asked Questions:
- Why PBN? What is PBN? How is it integrated in the Air Traffic system?
- Main benefits of PBN.
- Main navigation requirements and capabilities.
- Main procedure design and validation process.

This document is presented for information only, and is not intended to replace ICAO guidelines or National Aviation Authorities (NAA) mandated requirements.

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FAQ on Point in Space (PinS)

PBN Related FAQs

1. *What is Point in Space (PinS)?*

PinS are helicopter specific procedures for approach and departure that uniquely include both a visual segment and an instrument segment. PinS procedures are based on the Global Navigation Satellite System (GNSS) to impart flexibility in helicopter operations by taking advantage of the low-speed maneuvering capabilities of a helicopter. PinS enable IFR procedures to be carried out in non-instrument landing areas, which greatly enhances accessibility to helipads in obstacle-rich environments. Being an IFR procedure, it results in fewer flight disruptions when meteorological conditions are worse than VMC, while at the same time offering a higher degree of safety against risks of CFIT during approaches and take-offs in degraded visual environment conditions.

2. *So why is it called Point in Space?*

A PinS departure procedure gives the procedure designer the flexibility to position the Initial Departure Fix (IDF) anywhere in space at or above the IDF minimum crossing altitude (MCA) in an obstacle-rich environment. This is made possible because the first segment (which is the visual segment from landing area to IDF) can either be a direct visual segment flown directly to IDF, or a maneuvering visual segment where the initial take-off can be in a direction other than directly to the IDF and the helicopter is maneuvered in a climbing turn to intercept the IDF waypoint. The term PinS is thus derived from the freedom to position IDF anywhere in space above the IDF MCA, and similarly also the MAPt in any direction irrespective of take-off heading or approach heading, which literally endows the IDF and MAPt with the ability to become a point in space.

3. *Are the uniqueness of the visual and instrument segment and the possibility to position IDF literally anywhere in space above the IDF MCA the only two aspects that set PinS apart from airplane instrument procedure?*

These two are the most important differences, and the other is speed. Since speed is the most significant performance factor for airspace and visibility required for maneuvers in instrument approach procedures, speed in a PinS procedure is even less than in the airplane procedures designed for the lowest airplane speed of Category A. This enables procedures with a smaller turn radius to be designed for helicopters in obstacle-rich and constrained environments.

4. *Is PinS a part of PBN or is it something different because it is for helicopters only?*

PinS uses navigation information from the GNSS and is therefore dependent on GNSS technology for its functional use, which places a demand on the accuracy, integrity, continuity, and functionality needed during PinS. In other words it imposes performance requirements for the helicopter operating on an instrument approach procedure in a designated airspace, which means that PinS is a part of PBN. PinS is a helicopter-only procedure and designated as CAT H which is comparable to Category A airplane procedures but having essential criteria differences and lower speeds.

5. *Since PinS is an instrument procedure, can we assume that there is obstacle protection in the take-off and approach area?*

Obstacle protection is provided at all times for the instrument segment beyond IDF for departures, and until the end of the missed approach segment for approaches. However, for the visual segment, up until IDF for departures and below OCA/H, and beyond the MAPt for approaches, obstacle protection is conditional on PinS instructions being either ‘proceed VFR’ or ‘proceed visually’.
In the case of departure or arrival under ‘proceed VFR’ PinS instructions, there is no obstacle protection and the obligation is on the pilot to see and avoid obstacles while remaining in VFR conditions until reaching IDF during departure climb, or during approach procedure after the MAPt when landing.
In the case of departure or arrival under ‘proceed visually’ PinS instructions, obstacle protection during take-off is provided until climbing to the IDF. Obstacle protection is provided both for direct path (the direct visual segment), and also if the procedure is designed with indirect path (within and through the visual maneuvering area).

6. *What is the meaning of "proceed VFR” and "proceed visually”, because both terms seem quite similar?*

“VFR” includes specified minimum meteorological conditions established by the State for the airspace in which the operation is conducted, or the applicable operating regulations. “Visually” refers to meteorological conditions permitting visual reference to the surface but not necessarily meeting specified minimum meteorological conditions for VFR operations.

The visual segment of a PinS departure from the landing area until climb to IDF can either be with instructions to "proceed VFR” or "proceed visually”. In both cases the pilot has to navigate by visual references to see and avoid obstacles. The key difference is that, in case of "proceed VFR”, the operating minima is limited to the promulgated VMC minima for the PinS airspace, and the visual segment of flight is flown under VFR flight rules.

In the case of a "proceed visually” instruction, the flight may be conducted below the minima required for VFR and is consequently flown under IFR flight rules. The visibility and ceiling limits are defined so that visibility is sufficient to return to the heliport if the flight cannot continue visually to intercept the IDF.

The reason these two types have been established is that "proceed visually” has obstacle protection, which means that it is applicable for non-instrument heliports or landing areas which are compliant with ICAO Annex 14 Volume II, but not necessarily compliant with the Appendix of ICAO Annex 14 Volume II relating to instrument heliports. For landing areas which are not compliant with ICAO Annex 14 Volume II, it would be impossible to assure obstacle protection, hence ‘proceed VFR’ has been established for such a case.

7. *PinS is an instrument procedure, but someone told me that the flight rules during take-off can be either VFR or IFR depending upon the instructions for the visual segment. Isn't this quite confusing?*

Yes, the flight rules can be VFR or IFR depending upon the PinS departure instruction ('proceed visually' or 'proceed VFR') in the instrument flight procedure.
The flight rules in 'proceed visually' are IFR from take-off but flown visually to IDF. The flight rules in 'proceed VFR' are VFR at take-off, obtain permission for IFR before IDF and change to IFR after IDF.

8. *Is there a relationship between a helicopter-specific NavSpec like RNP0.3 and PinS?*

RNP 0.3 is a navigation specification used within areas of operations which are en-route continental, SIDs/STARS, and in the terminal procedural environment. PinS is an approach procedure. RNP 0.3 navigation specification is not applicable in the final approach segment. Although it can be noted that PinS is RNP APCH, and the lateral precision required in the final approach segment after FAF is 0.3 nm.

9. *How is PinS related to RNP APCH? Is PinS a type of RNP APCH?*

In terms of PBN concept there are two types of navigation application during the approach phase of flight - RNP APCH or RNP AR APCH. PinS is an instrument flight procedure for which the approval is RNP APCH (currently the minimum for PinS is down to LNAV or LPV minima). The RNP APCH requires precision parameters (1.0 NM in the initial, intermediate and missed segments and 0.3 NM in the final segment), presence of On-board Performance Monitoring and Alerting (OBPMA) and approved equipment, approved aircraft and flown by an approved flight crew. PinS is not a type of RNP APCH but an instrument procedure that requires RNP APCH requirements to be adhered to.

10. *Is PinS helicopter specific?*

Yes, PinS is only applicable to helicopters.

Procedure Related FAQs

11. *Does PinS have to connect to an IFR route or can I fly VFR after the PinS point during departure?*

PinS is an instrument flight procedure that should connect to an ATS route. This means that in a PinS departure procedure, after crossing IDF, it would connect to an ATS route; similarly during approach, at the terminal area, PinS would commence from IAF and could also include the initial, intermediate, final and missed approach segments.
While it is possible that after IDF, the flight rules can be changed to VFR by the pilot not electing to fly IFR by choice, by procedure design the PinS IDF will connect to an ATS route requiring IFR flight rule.

12. *I have heard that on PinS approach, after the MAPt, one can turn and proceed to Descent Point. What is Descent Point, is this lower than the MAPt and is it in the same direction of approach?*

Any visual flight maneuvering beyond the MAPt assumes that adequate visual or VFR conditions exist to see and avoid obstacles. However, due to geography and terrain constraints, a particular landing area may not be visible from the MAPt although adequate visual or VFR conditions exist. In such a case, a descent point (DP) identified by defined track and distance from the MAPt can be established.
This allows the helicopter to level off at MDA at the MAPt, and continue in level flight until DP whereby, on sighting the landing area, final descent can be commenced. The DP for such landing areas can either be placed such that it requires course change up to 30° at the MAPt and fly to DP, or without course change at the MAPt fly to DP and then undertake a course change up to 30° to descend for landing. DP is never lower than the MAPt (at MDA) and is limited to a course change of up to 30°.

13. ***In an approach, I understand that I can 'Proceed Visually' or 'Proceed VFR'. How distant can the helipad be after the PinS MAPt? Can the distance be more than 5 kms?***

In the case of 'proceed VFR', there is obviously no limit for the VFR segment since the flight rules require the pilot to see and avoid obstacles. For 'proceed visually', which would be undertaken in less than VFR conditions, the distance from the MAPt to the landing area depends on visual conditions to identify the helipad in approach while also ensuring that sufficient distance is available to decelerate, descend and land the helicopter. Accordingly, the maximum visual segment length from the MAPt to the landing area is 3 km.

14. ***After the MAPt, can I carry out a curved approach to the helipad doing PinS?***

For PinS with a direct visual segment, there would be no requirement for a curved approach since a direct path would be accessible from the MAPt to the landing area. The requirement for a curved approach can only exist in cases where a maneuvering visual segment is imposed. Curved approach from the MAPt to the landing area would be required in order to stay within the maneuvering area with bank turn not exceeding 30° and speed less than 50 KIAS.

15. ***I have seen a PinS departure with a Maneuvering Visual Segment. In such a case, do I need to maneuver according to a prescribed path or be anywhere within this maneuvering area?***

The purpose of a maneuvering visual segment is to protect the turn maneuver whereby the pilot visually acquires the heliport or landing location, or visual references associated with it, by the time he reaches the MAPt, and visually maneuvers around the heliport or landing location to land from a direction other than directly from the MAPt. Since the entire maneuver area is protected, the pilot is free to maneuver anywhere within this area from the MAPt to the point where it is aligned on the final landing.

16. ***Am I protected from obstacles in the 'Proceed Visually' segment?***

Yes, obstacle protection is provided for 'proceed visually' instructions whereas no protection is provided if the instruction is 'proceed VFR'. Protection is included for maneuvering visual segment areas.

17. ***What is the maximum and minimum vertical path angle in a PinS departure and arrival?***

For approaches, the nominal/maximum descent angle from the MAPt or DP to the landing HRP is 8.3°. This is also known as visual segment descent angle (VSDA), which is the nominal descent path of the aircraft in the visual segment. For departures, the nominal procedure design gradient during the visual phase is 7.6° until reaching the IDF minimum crossing altitude. This gradient shall not be less than 0.46° above the ICAO Annex 14 take-off climb surface.

18. ***What is the lowest height at which a PinS can be created?***

The lowest OCH in a PinS procedure can be for a maneuvering visual segment which shall not be less than 90 m (295 ft) above the heliport/landing location elevation.

Aircraft Related FAQs

19. What is the equipment needed for PinS in my helicopter?

The most essential equipment for PBN is a GPS receiver with On-board Performance Monitoring and Alerting (OPMA) feature. OPMA detects and informs aircrew that the RNP system is not achieving the navigation performance required of the RNP system. Non-OPMA GPS receivers can be utilized for RNAV but not for RNP operations. PinS does not strictly require GPS receivers that are SBAS capable unless the approach is 3D or APV capable. The minimum GPS standard for PinS is TSO-C129 compliant, though SBAS compliant standards of TSO-C145/146 can also be used.
However, national aviation authorities may specify regulations for the minimum equipment considered for IFR flight rules and this may impose the need for an autopilot or stability augmentation system. The equipment fit would therefore need to be checked with the local aviation regulator to ensure that it meets IFR requirements. Nevertheless, PBN approval from the aviation regulator requires equipment level approval, aircraft level approval, operator level approval and aircrew qualification.

20. So, could you briefly tell me what the difference is between GPS receivers which are TSO-C129, and those that are TSO-C145/146?

The difference between ordinary GPS receiver and aviation-spec is that the latter has Receiver Autonomous Integrity Monitoring or RAIM. RAIM is a technology to assess the integrity of GPS signals. An ordinary GPS receiver which is without RAIM, will solve for position and time using signals from a minimum of four GPS satellites.
A GPS receiver with RAIM (TSO-C129 compliant), requires a fifth satellite, or barometric aiding, to perform a consistency check to detect a fault on a single satellite. Although it is possible that a TSO-C129 compliant receiver could have an optional FDE capability.
A GPS receiver with SBAS (TSO-C145/146 compliant), also uses RAIM, but adds a fault detection & exclusion (FDE) feature requiring a minimum of 6 satellites to detect and exclude a faulted satellite. Instead of declaring a GPS SPS service unusable with a RAIM alert, RAIM/FDE excludes the bad satellite and continues to provide an integrity-assured solution, provided the geometry of the remaining satellites in view is sufficient.

21. I was told that PBN requires instruments for IFR such as autopilot. Does my single engine helicopter with no autopilot qualify for PinS?

PBN requires an IFR flight plan and the crew requirements for IFR differ between national aviation authorities. The regulations in some countries may require autopilot, but in terms of PBN, the GPS could be a sensor in a multi-sensor system or a self-contained and stand-alone navigator. This would require at least a flight director so it is possible that in some countries single engine helicopters with no autopilot could have the helicopter and equipment certified and approved for PBN.

22. I have an old GPS system on my helicopter. How can I know if this is RAIM or SBAS capable GPS receiver?

The minimum GPS requirement for PBN is to have RAIM, and this would mean it is TSO-C129 compliant. PinS needs this minimum requirement unless an approach is 3D APV, which requires SBAS and also TSO-C145/146 compliance. The manual of the installed GPS would identify the correct GPS technical standards.

23. My old helicopter does not have GPS fitted on the aircraft but I fly with a portable GPS that is hooked up to my iPad running ForeFlight. Can I do PinS using this setup?

PinS requires RNP APCH which means approval from the aviation regulator for equipment level approval, aircraft level approval, operator level approval and aircrew qualification. Since no GPS is fitted on the helicopter in this case, it would not satisfy all the conditions and it would not be possible to receive RNP APCH approval to conduct PinS.

Flight Plan Related FAQs

24. *When planning for a PinS departure, is the flight plan filed as VFR or IFR?*

If the PinS instrument flight procedure mandates 'proceed VFR' then the flight plan is initially VFR with a changeover to IFR at IDP. In case of 'proceed visually' instructions, the flight plan can be IFR from commencement.

25. *What are the planning issues for deciding IFR alternates when filing a flight plan with PinS departure and/or arrival?*

The normal rules for IFR alternates apply for arrival procedures. Under EASA the rules for IFR alternates have been relaxed for some helicopter type operations. For departures, being a visual procedure, the alternative can be to return to the take-off landing area.

26. *Can the PinS be published as a SID/STAR for an airport?*

Yes, PinS departure after IDP can connect to a SID and similarly after STAR can feed into a PinS approach procedure.

Airspace Related FAQs

27. *As a pilot do I need to have some extra qualifications to carry out PinS?*

Yes, aircrew will need PBN training and qualification for knowledge and proficiency in PBN procedures, which would include, amongst others, RNP system-specific knowledge, instrument approach/departure procedures, knowledge of radiotelephony phraseology for RNP applications, and the ability to conduct contingency procedures following RNP system failures. The training content and approval process may be different according to different aviation regulators worldwide.

28. *In airspace with the 'Proceed VFR' segment, is the pilot responsible for obstacle avoidance?*

Yes, the normal VFR responsibilities apply, and these require the pilot to apply the principles of 'see and avoid' for obstacle avoidance.

29. *Is the Air Traffic Controller responsible for maintaining traffic separation in the Proceed Visually or Proceed VFR segments?*

'Proceed VFR' segment entails responsibilities for the pilot and for the controller, as in the case of any other VFR flight. The responsibility of the air traffic controller in 'proceed VFR' is no different than VFR flight and depends on the airspace type and class where the flight is being performed.

30. *For undertaking PinS, is there a requirement for helipads to be compliant with ICAO Annex 14 Vol II standards?*

ICAO Annex 14 Vol II prescribes the physical characteristics and obstacle limitation surfaces and technical facilities for a heliport. In the case where the landing area conforms to ICAO Annex 14 Vol II but not to the Appendix, which lays down standards for instrument heliports for precision and non-precision approaches, the instrument flight procedure design for PinS would be with a 'proceed visually' instruction. In the case where the landing area is not compliant with ICAO Annex 14 Vol II, the PinS design would be with 'proceed VFR' instructions.

Hence, it is not necessary for a landing area to be compliant with ICAO Annex 14 Vol II for PinS, but it can be understood that compliant landing areas can be with the 'proceed visually' instruction permitting operations in visual conditions less than VMC.

1. Why PBN? What is PBN? How is it integrated in the Air Traffic system?

1.1. Why PBN?

Helicopters have been in operation for many decades, and helicopter operations are not yet fully integrated into the air traffic management (ATM) network. Many helicopter operations continue to be performed under visual flight rules (VFR) in visual meteorological conditions (VMC). Vital missions such as helicopter emergency medical services too are mostly performed under VFR in clear day/night and at times even in lower visibility conditions with special approvals from local authorities. Whereas VFR/VMC limit helicopter availability for critical missions, flying in low visibility conditions imposes significant risks on overall flight safety. Studies that have analyzed past helicopter accident records identify numerous causal factors and risks. Of those factors, pilot judgment and actions were the leading causes of all accidents. Of the identified risks, inadvertent entry into instrument meteorological conditions (IMC) and controlled flight into terrain (CFIT) have catastrophic consequences. There is also evidence to suggest that helicopter pilot performance drops significantly upon inadvertently encountering IMC.

Many of today's commercial helicopters are certified to operate in instrumental conditions under instrument flight rules (IFR), and offer advanced onboard avionics and flight automation. It is therefore essential that IFR procedures be adopted not only to enhance the safety of helicopters, but also to enable their seamless integration into the current and future ATM frameworks.
The transition from conventional ground navigation aids to a system based on the Global Navigation Satellite System (GNSS) has revived interest in IFR procedures for helicopter operations. GNSS provides a ubiquitous, reliable, and accurate means of navigation, thus making it an ideal enabler of helicopter IFR procedures. The performance of GNSS has been further enhanced by satellite-based augmentation systems (SBAS), such as the European Geostationary Navigation Overlay Service (EGNOS) in Europe and the Wide Area Augmentation System (WAAS) in the United States, and has led to more accurate onboard navigation capabilities.

For decades, in order to fly IFR from Departure to Arrival, the helicopter industry used conventional navigation systems and radio navigational aids (NAVAIDS), for example VOR/DME, NDB.
Due to the constant growth in traffic, the requirements for an increase in airspace capacity and flight efficiency pushed these conventional navigation systems to their limits:
- A large number of NAVAIDs is required to cover a large area because of their limited range.
- The maintenance of these NAVAIDs generates high costs.
- The limited flexibility of the NAVAIDs (based on bearing/distance and radial interception principles) offers limited flight efficiency (e.g. non-direct routes, non-curved approaches).

We are currently part of a global transition to PBN, it offers a lot of benefits to both fixed-wing and rotary IFR traffic such as more efficient routes, increased capacity and an improvement in safety. It is especially exciting for the helicopter industry, as it will allow for instrument approaches to elevated (hospital) helipads and low-level IFR routes.

The new method of navigation, also referred to as Area Navigation (RNAV), enables the aircraft to fly from **waypoint** to **waypoint** (defined by latitude and longitude coordinates) instead of from NAVAID to NAVAID, as illustrated in Figure 1.

Figure 1: RNAV versus Conventional trajectory

The introduction of the FMS navigation system enables the estimation of the aircraft navigation error.

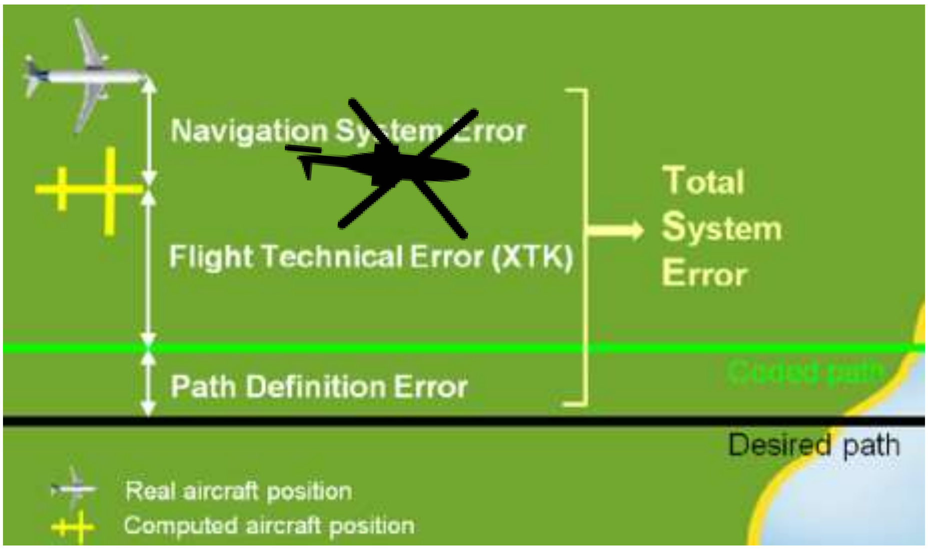

Figure 2: Total System Error split

As illustrated in Figure 2, the Total System Error (TSE) on aircraft navigation includes the following components:

- The **path definition** error, which is the difference between the desired flight path and the flight path encoded in the Navigation Database (NDB). This component is considered to be negligible on the basis of the navigation database validation.
- The **flight technical** error is based on the piloting and flight guidance performance represented by the cross-track deviation (XTK).
- The **navigation system** error is based on the aircraft position error computed by the systems.

The Performance-Based Navigation (PBN) concept was created based on the capability to quantify this Total System Error.

On this basis, the PBN concept enables the design of procedures that reduce the separation with obstacles and the separation between aircraft.

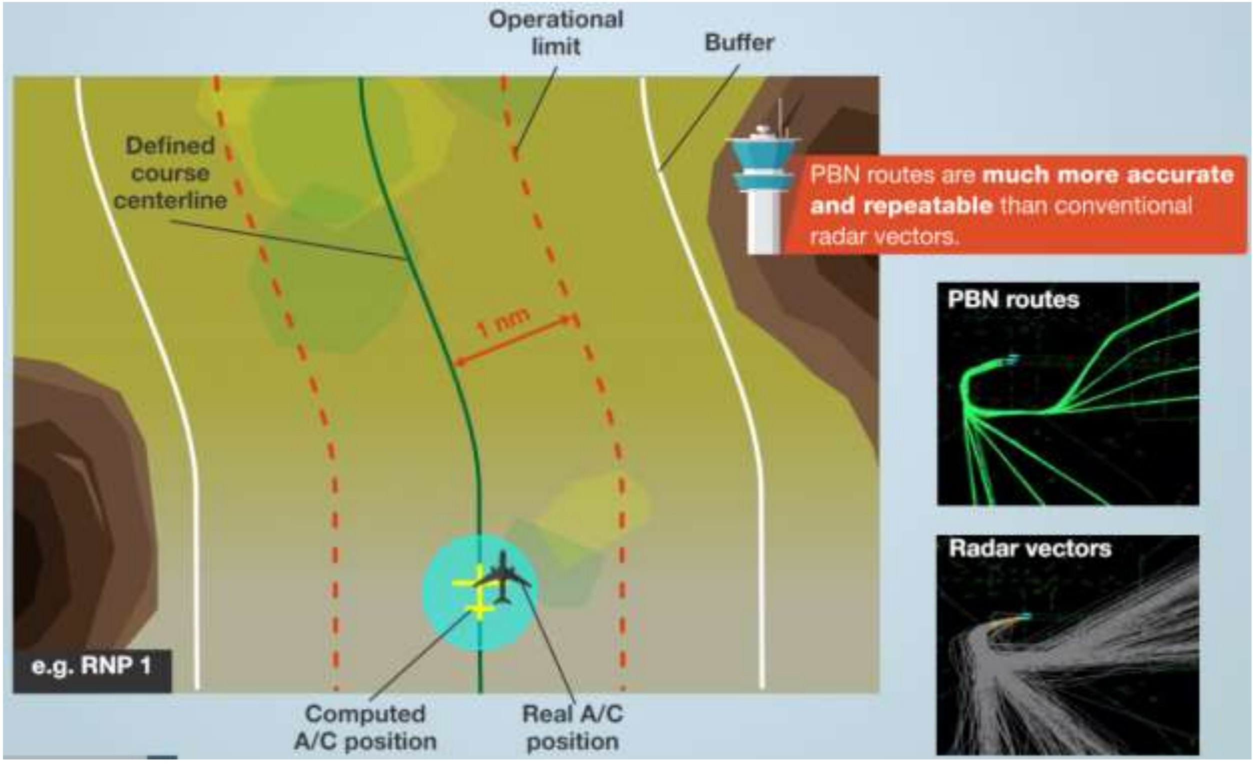

Figure 3: RNP1 lateral corridor

To achieve this objective, the PBN concept specifies the following basic definitions of navigation performance:

- Navigation precision answers to “How accurate is it?”
- Navigation integrity answers to “How much can it be trusted?”
- Navigation availability answers to “How often can it be used?”
- Navigation continuity answers to “How often will it be interrupted”

Figure 4: PBN performance criteria

1.2. What is PBN?

1.2.1. General

PBN stands for Performance Based Navigation.
The PBN concept represents a shift from defining navigation according to the sensor being used, such as VOR, DME, ILS, etc., to one based on specifying a required level of performance.

PBN creates a series of specifications that are to be used for navigation.
PBN defines these specifications in terms of what level of performance is required to be met in a specific phase of flight.

Based on these definitions, several local initiatives defined their own requirements to fly some Area Navigation (RNAV) or Required Navigation Performance (RNP) operations. This emerging environment led the ICAO to publish the PBN manual (ICAO Doc 9613) and the PANS–OPS amendment (ICAO Doc 8168) in order to standardize the PBN concept for area navigation. The PBN manual specifies the scope of each RNAV and RNP operation.

Navigation Specification	Flight Phase – Navigation Application and Lateral Navigation Accuracy (NM)								Additional Functionalities (Required or Optional)					
	ATS or User Preferred Routes		Arrival Procedures	Approach				Departure Procedures						
	En route oceanic / remote	En route Continental	Arrival	Initial	Intermediate	Final	Missed[1]	Dep	RF	FRT [c]	VNAV (Final Segment)	Parallel Offset [d]	Hold [e]	TOAC
RNAV 10	10													
RNAV 5[2]		5	5											
RNAV 2		2	2					2						
RNAV 1		1	1	1	1		1	1						
RNP 4	4									O		R [d]		
RNP 2	2	2								O				
RNP 1[7]			1	1	1		1	1	O [a]	O		O [d]		
Advanced RNP	2[3]	2 or 1	0.3	0.3	0.3		0.3	0.3	R [a]	O		R [d]	R [e]	
RNP APCH[4]				1	1	0.3[5]	1		O [a]		O (SBAS or Baro)			
RNP AR APCH				1 – 0.1	1 – 0.1	0.3 – 0.1	1 – 0.1		R [b]		R (SBAS or Baro)			
RNP 0.3[6]		0.3	0.3	0.3	0.3		0.3	0.3	O [a]					

Figure 5: Navigation Specifications and Lateral precision per Flight Phase

1.2.2. RNAV and RNP

As seen above, there are 2 main sets of specifications. RNAV (aRea NAVigation) and RNP (Required Navigation Performance).
RNP stands for required navigation performance, and the only way this is different from RNAV is that it requires onboard performance monitoring and alerting.

RNAV □ Capability to fly any desired flight path, defined by waypoints such as geographic fixes (LAT/LONG) and not necessarily by ground navaids.

RNP □ GNSS based + OBPMA.

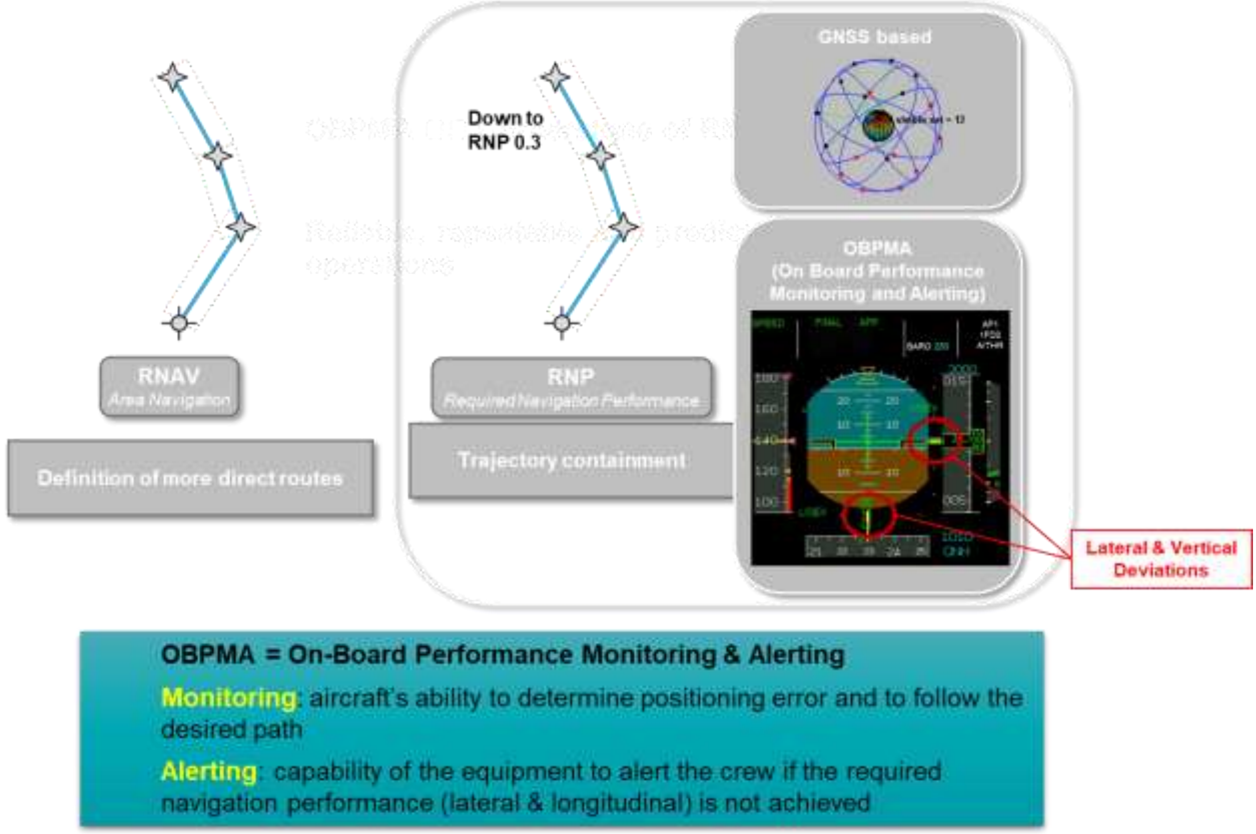

Figure 6: RNAV vs RNP main differences

An RNP system uses OBPMA to guarantee the level of precision and integrity of the navigation signals being received. It relates to both lateral and longitudinal navigation performance.
OBPMA monitors the level of precision and alerts the pilot in real time when the required level of precision is not being achieved. OBPMA is used to ensure that the RNP system is performing as expected. OBPMA relies on the Receiver Autonomous Integrity Monitoring, in short, the FDE function of the RNP-equipped aircraft. RAIM is the process by which navigational integrity is guaranteed by detecting any GNSS discrepancy.
As a part of pre-flight planning, a pilot must use a RAIM prediction tool before departing, to predict when and where GNSS functions may not be available during the flight.
That is to say whether or not there will be a sufficient number of satellites in view, and/or suitable constellation geometry during the flight to provide RAIM information.
During the flight, RAIM is the process that the GNSS receiver uses to assess the precision and integrity of the navigation signals being received.
Integrity describes the measure of trust that can be placed in the correctness of the information supplied by the entire system.
RAIM includes the ability of the system to provide timely and valid warnings to the user.

1.2.3. The Navigation specification levels

In the following chapters, only the navigation specifications mostly applied for helicopter operations will be detailed.

1.2.3.1. RNAV 1

These procedures are mainly used for terminal area (initial/intermediate/missed approach and departure), for SID and STAR, also known as RNAV SID and RNAV STAR. The RNAV 1 procedure is the minimum required precision in most of the terminal environment.
RNAV 1 operations were initially deployed to accommodate terminal area procedures in smaller airspace. RNAV 1 is also an intermediate step towards the RNP procedure in the terminal area.
According to the design criteria, the aircraft lateral performance must be less than or equal to 1 NM.
Concerning the definition of RNAV operations compared to RNP operations, RNAV1 does not require an OBPMA. Performance monitoring is ensured by ground ATC monitoring. However, the recent Airbus Helicopters fleet (from H225 to Helicopters equipped with Helionix avionics suites) is equipped with FMS providing an on-board monitoring function, therefore the RNAV procedure is operated and monitored as an RNP procedure.

1.2.3.2. RNP 1

These procedures are mainly used for terminal area (initial/intermediate/missed approach and departure), for SID and STAR, also known as RNAV SID and RNAV STAR with RNP 1 capability. Within a low to medium density traffic area, the RNP 1 routes connect the terminal airspace to the en-route structure with a limited ATS surveillance.
RNP 1 is based on GNSS. This navigation specification mainly applies for environments where the DME infrastructures cannot support DME/DME area navigation at the required performance level.
Depending on the design criteria (RNP value equal to 1 NM), the aircraft lateral performance must be less than or equal to 1 NM.
The GNSS position is required and monitored (see chapter 3).

1.2.3.3. RNP 0.3

Used to support helicopter RNP operations in all phases of flight except final approach.
RNP 0.3 is a specification which is mainly used by helicopters and will be used in the future for low-level IFR routes, and which is already being used in certain places in Europe for routes which transition into/from a visual phase of flight (approaches or departures to/from a helipad). This technique is also referred to as Point in Space (PinS) operations.

1.2.3.4. RNP APCH with LNAV minima

RNP APCH operations are used from IAF to the end of the missed approach.
RNP APCH provides an operational solution for airport runways which are not equipped with precision approach systems, or as a backup service in the case of inoperative precision approach systems (i.e. failure, maintenance or snow conditions).

RNP APCH procedure design considers the following requirements:
- During initial, intermediate and missed approach, the protection area around the flight path corresponds to the RNP 1 criterion.
- After the FAP (or FAF): The final leg is straight.

The procedure design criterion detailed in the ICAO PANS/OPS does not consider the possibility of implementing helicopter RNP approaches down to LNAV/VNAV minima, it uses barometric vertical guidance.

The criterion of RNP 0.3 applies during the final approach segment, as it is an LNAV minima criterion. If the approach is flown to LNAV minima, the vertical obstacle clearance is ensured by crossing altitude on specified fixes, as illustrated in Figure 7.

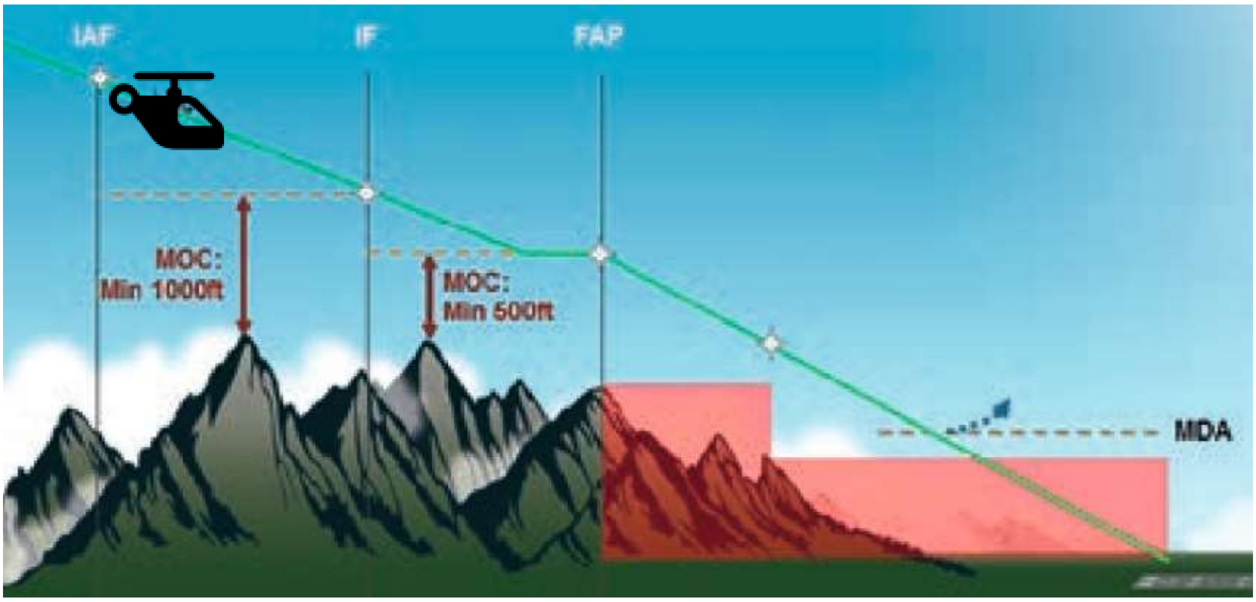

Figure 7: Example of Vertical Design Procedure for RNP APCH with LNAV Minima

1.2.3.5. RNP APCH with LPV minima

The RNP APCH procedure can be operated down to LPV minima. LPV stands for Localizer Performance with Vertical guidance. This approach uses the Satellite-Based Augmentation System (SBAS).
The SBAS technology provides a geometric reference for the vertical guidance definition: The augmented GNSS altitude is used instead of the barometric Altitude.

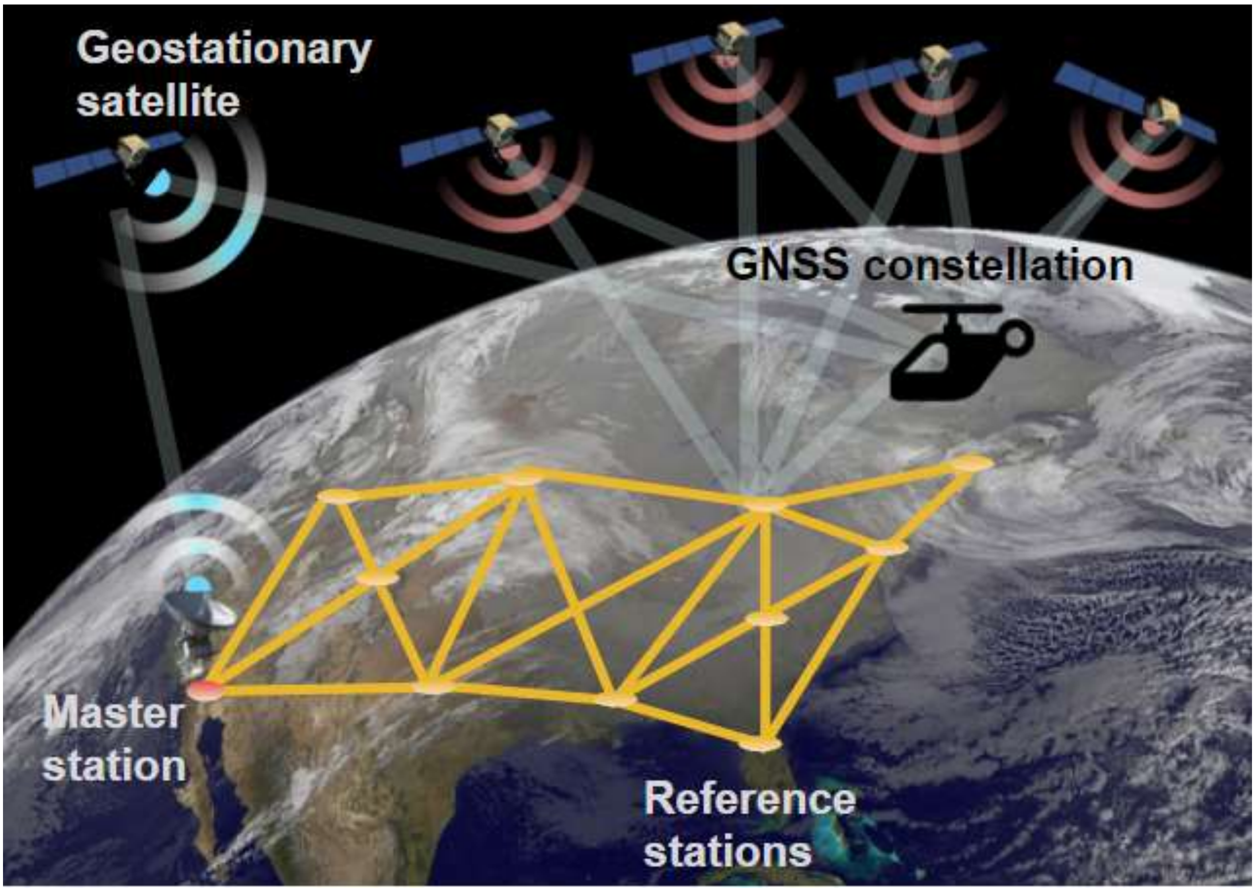

Figure 8: SBAS system scheme

RNP APCH with LPV minima is an approach with vertical guidance (the lowest decision height is 250 ft). However, by adding specific requirements, it could enable precision approach operations facilitating an OPS minima criterion similar to ILS CAT I operations. In this case, RNP APCH with LPV minima enables decision height as low as 200 ft depending on obstacle clearance (SBAS CAT I operation).

1.2.3.6. <u>Point-in-Space (PinS) concept</u>

The Point-in-Space (PinS) concept is a flight operation based on GNSS and designed for helicopters only. It relies on the possibility for the pilot to conduct flight under Instrument Meteorological Conditions (IMC) to/from a specific waypoint (PinS) and not directly to/from the heliport. Those procedures enable heliport or landing site operators to implement IFR procedures on non-instrument FATO (Final Approach and Take-Off) located on aerodromes or isolated heliports as well as landing locations.
Another advantage of the PinS concept is the flexibility to position the PinS in order to deal with heliports generally located in obstacle-rich environments (heliports on hospitals for instance). For approach, this flexibility allows a lower Obstacle Clearance Height (OCH) than with the direct procedure, due to the position of the MAPt which can be located away from the FATO and makes the missed approach less critical regarding obstacles.
Two types of PinS operations are possible: PinS departure operations and PinS approach operations.

PinS departure operations

The PinS departure procedure consists of a visual segment followed by an instrument segment. The visual segment of the departure starts from the heliport or landing location and ends at the initial departure fix (IDF) at or above the IDF minimum crossing altitude (MCA).

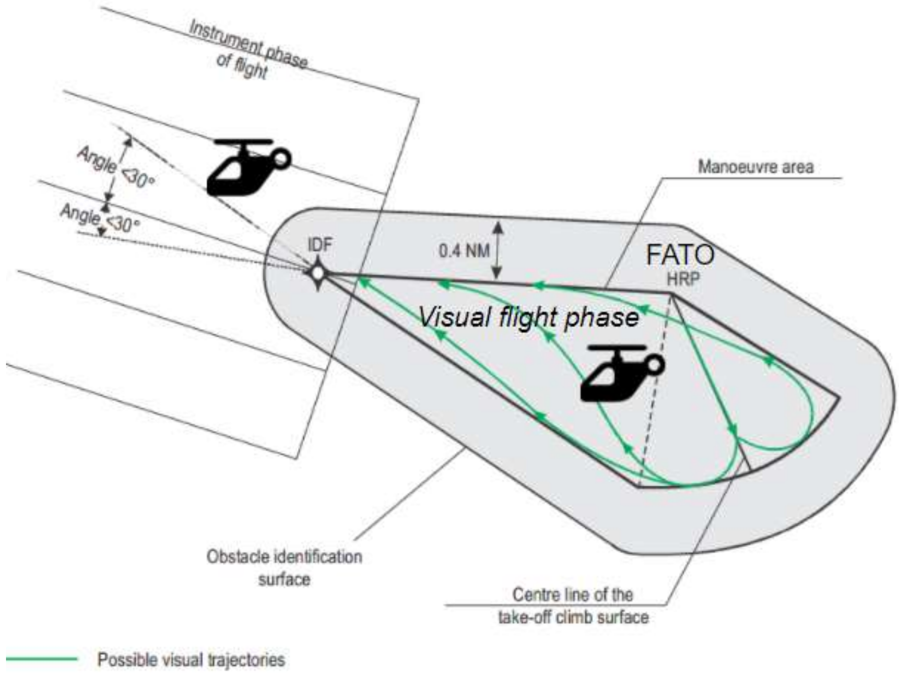

Figure 9: PinS 'Proceed visually' departure with visual maneuvering area

- *Visual flight phase*: Proceeds using visual references from FATO to the IDF. Two options:
  - 'Proceed visually' procedure
    - Direct visual segment
    - Maneuvering visual segment
  - 'Proceed VFR' procedure
- *Instrument flight phase*: Once passed IDF at or above a specific altitude (MCA)

➔ NAV SPEC – **RNP1** or **RNP0.3**

PinS approach operations

The PinS approach procedure consists of an instrument segment followed by a visual segment. The visual segment of the approach starts from a specific waypoint (MAPt) at or above the obstacle clearance altitude (OCA) and ends at the heliport or landing location.

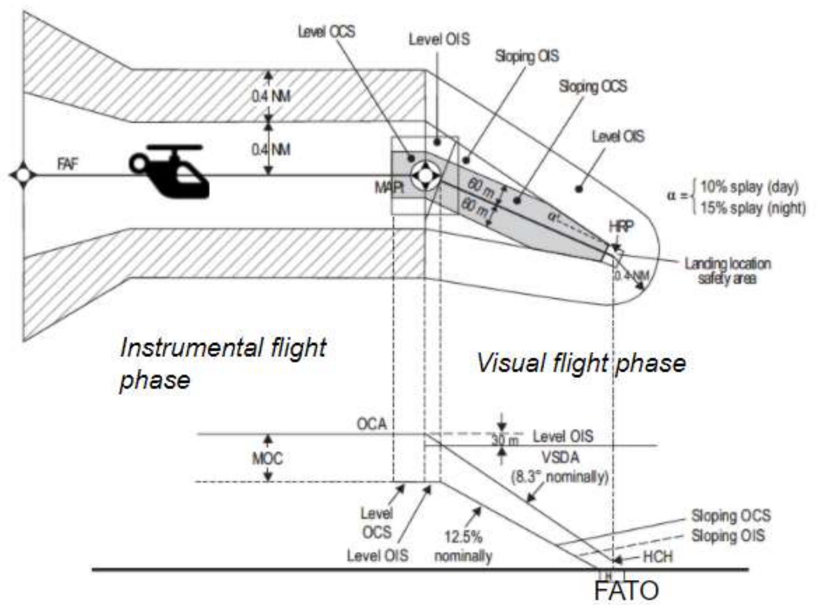

Figure 10: PinS 'Proceed visually' approach with direct visual segment

- *Instrument flight phase*: Includes all segments, initial, intermediate, final and missed approach
- *Visual flight phase*: Proceeds using visual references from the MAPt to the FATO. Two options:
  - 'Proceed visually' procedure
  - 'Proceed VFR' procedure

Note : For the meanings of abbreviations, refer to acronym list.

➔ NAV SPEC - **RNP APCH** (**LNAV** or **LPV** minima)

1.3. How is PBN integrated into the air traffic system?

1.3.1. General

The PBN concept is just one aspect of the complete air traffic system used for moving aircraft through an airspace. Airspace planners and designers need to understand the interdependence of the airspace concept with the navigation system capability, and to view both in context with other enablers (communications (COM), surveillance (SUR) and air traffic management (ATM) procedures and tools). The benefits derived from the implementation of the PBN in a specific airspace must compensate for the cost of aircraft navigation and air traffic control (ATC) system equipment, pilot and ATC training, as well as airspace and procedure design arising from the implementation.

PBN is about navigation (aircraft positioning and guidance).

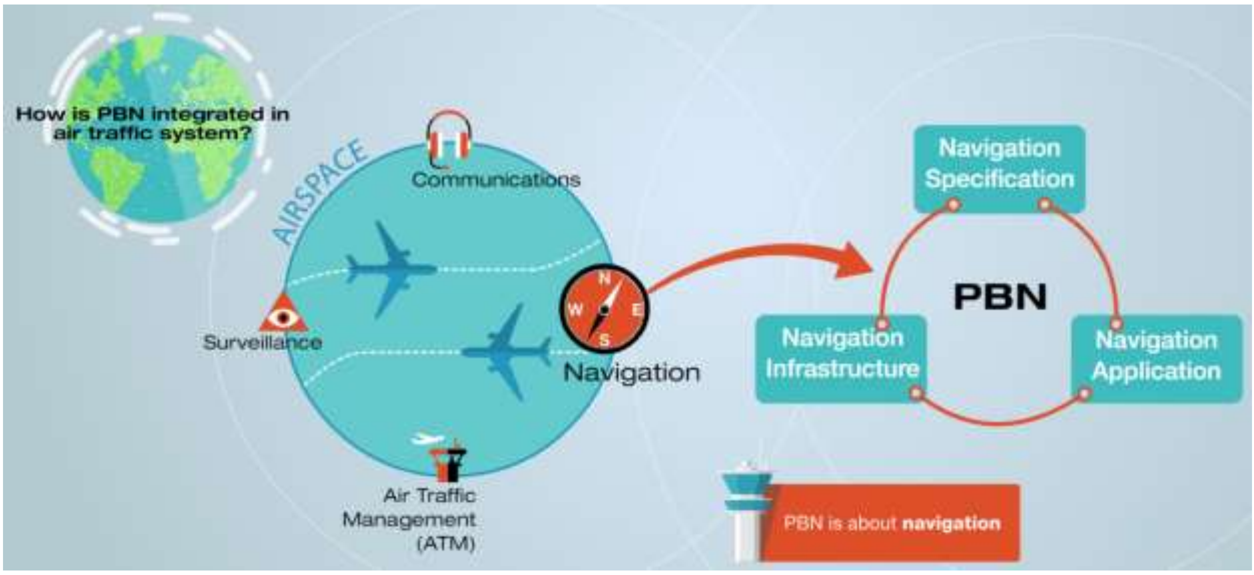

Figure 11: PBN integration into Air Traffic System

PBN consists of three components:

- Navigation specifications: answers to “What level of performance is required?”
  - For example remain within 1 NM of course centerline, remain within 5 NM of course centerline, or have a specific function to fly a parallel offset from the nominal track, etc.

- Navigation infrastructure: answers to “What navigation sensors can be used?”
  - For example GNSSS, VOR/DME, DME/DME, Inertial Navigation System etc.

- Navigation application: answers to “What are we applying PBN to?”
  - For example: SIDs, STARs, airways, approaches etc.

In addition, PBN operation can be performed in different type of airspace, i.e. controlled but also uncontrolled airspace (Class G).

1.3.2. Navigation specifications

The Navigation Specification prescribes the performance requirements in terms of precision, integrity and continuity for proposed operations in a particular Airspace or on a specific procedure. The Navigation Specification also describes how these performance requirements are to be achieved, i.e. which navigation features are required to achieve the prescribed performance. Associated with the navigation specification are requirements related to pilot knowledge and training and operational approval. A Navigation Specification is either an RNP specification or an RNAV specification. An RNP specification includes a requirement for on-board self-contained performance monitoring and alerting while an RNAV specification does not.
This part has been described previously in 1.2.3 The Navigation specification levels.

1.3.3. Navigation infrastructure

The Navaid Infrastructure relates to ground- or space-based navigation aids that are called up in each Navigation Specification (one navigation specification could be supported by one or several navigation sensors, or even a combination of them). The availability of the navaid infrastructure has to be considered in order to enable the navigation application.

1.3.4. Navigation application

The Navigation Application refers to the application of the Navigation Specification and Navigation Infrastructure in the context of an airspace concept to ATS routes and instrument flight procedures.

2. Benefits

Usually, helicopter operators have to face significant weather and terrain-related challenges when performing specific flight operations (e.g. civil transport, medical emergencies, etc.). For these reasons, and for decades, helicopter operations were suitably confined to flying only when they could meet strict visibility standards (VMC conditions), drastically limiting their access to controlled airspace and accordingly the operations to and from airports. In addition, low cloud, fog, rain, snow, the presence of mountains and valleys could seriously affect safety and the success of the operations concerned.
Nowadays, the GNSS technology enhanced by SBAS systems (without the need for ground infrastructure) allows the design of specific IFR approach and departure procedures, known as Point-in-Space (PinS) procedures. The GNSS technology provides the appropriate precision, integrity and availability for these new helicopter operations in controlled or uncontrolled airspace, considering the limitations associated with the current heliport infrastructure (non-instrument heliport).

The Point In Space operations are available in paragraph 1.2.3.6.

Furthermore, thanks to the development of RNP APCH, RNP1 and RNP0.3 navigation specifications, the ICAO PBN concept makes a wide range of benefits available, facilitating the full integration of helicopter operations into the ATM system.

Such dedicated helicopter flight procedures not only increase the capacities of TMA sectors, but should improve safety, flight efficiency, equity, accessibility and reduce the environmental impact (noise and pollution) in the airspace within the Terminal Maneuvering Area (TMA).

When IFR helicopters have advanced on-board avionics compliant with Performance Based Navigation, especially RNP 1, RNP 0.3 all phases of flight and RNP APCH, this allows them to fly the low-level routes and Point In Space procedures. The RNP 0.3 for any phase of flight is used for low-level route operations in mountainous environments, due to the narrow corridor associated with the low RNP value. In other cases, RNP1 (being less stringent) may be defined for this type of operation. Low-level routes are often defined to connect different landing sites such as hospitals, but also to airports/heliports in the TMA airspace. It also allows the creation of approaches on airports without interfering with the fixed-wing traffic, by the creation of SNI procedures (Simultaneous Non-Interfering).

IFR PinS procedures represent the best facilitation to allow helicopter operations on non-instrument heliports in controlled and uncontrolled airspace, and at the same time. They support connectivity between airports/heliports included in the TMA airspace, thanks to the implementation of the IFR Low-Level Routes concept.

The creation of low-level routes combined with point in space approaches on landing sites, provide an efficient network for helicopters to operate with minimal interaction with fixed-wing traffic. An efficient “tool” for IFR operations is provided.
When combined with the simplification of IFR operation for helicopters, which will greatly depend on operational regulation of the airspace of operation, this increases flight safety, especially in difficult weather conditions combined with challenging terrain, limiting cases where marginal VFR flights are performed. In addition, it increases operations in poor weather conditions, contributing significantly to increase the efficiency of the Helicopter Emergency Medical Services.

Helicopters reach their best operational performance when flying unconstrained in VFR, an operating mode which is heavily dependent upon weather conditions and visibility. However, this way of operating can be adversely affected by foggy or cloudy weather and icing conditions, which can prevent helicopters from applying ‘Proceed VFR’ or can subject them to delays when operating to/from a controlled airspace (i.e. CTR) in high/medium-complexity airspace.

Helicopters, IFR-certified with modern avionics, when flying to/from instrument heliports or landing locations (mainly airports, as few heliports are instrument heliports), due to the lack of helicopter-specific procedures, will use the same flight procedures originally designed for fixed-wing aircraft.
These approach and departure procedures, being specifically designed for fixed-wing aircraft, are constraining for helicopters and impose considerable limitations on their operations, due to flight trajectories and profiles which are not optimized for helicopters, as they can fly at lower speeds allowing different turn radii and with different climb rates and descent rates, typically up to 10°. In addition, this disrupts the traffic of fixed-wing aircraft due to the low speed of operation.

Approach procedures are therefore being developed more and more for helicopters, with different course changes between legs, different vertical path angles, different leg lengths compared to fixed-wing aircraft.

In addition, the minimum IFR speed provided by helicopters, in some cases as low as 30-40 Kts allows safe operation at the missed approach point providing more time to assess the external environment, and when the visual conditions are provided, proceed VFR/visual up to the FATO.

The available high vertical speed during climb allows a higher climb rate and thus provides safe missed approach operations in mountainous environments.

3. Pre-requisites and constraints

Point In Space compared to RNP approach

PinS approach is an RNP APCH application which can be defined with LNAV and LPV minima. But it is connected to a Point In Space far from the landing area. The flight from the point in space to the landing site is performed visually.

A standard use for helicopters is an approach to a helipad, such as a hospital.

When the avionics system is already certified for RNP APCH LNAV and LPV, it is prepared to provide the Point In Space capability.

A point in space can be associated with a single destination or several destinations or no destination at all. Not all types have the same level of maturity, regarding criteria to develop the procedure, procedure naming, and the way they are managed by FMS, especially to retrieve the procedure from the aeronautical database.

There is also one operational difference: RNP APCH down to LPV minima on runways are often performed considering back-navigation sources based on conventional navaids. This is not the case for PinS when defined in a mountainous environment and far from any aerodrome, and sometimes without reception of any ground navaids.

The operation is also more complex, due to the need for obtaining weather information (QNH value, visibility). When connected to a low-level route, icing risk must also be considered.

Minimal requirements

Different civil regulations, such as FAA Advisory Circular AC20-138(), and EASA Certification Specifications and Acceptable Means Of Compliance which relate to Airborne Communication Navigation Surveillance, CS ACNS, define the minimum requirements for navigation systems, performance and failure classification for any RNP application as defined per PBN.

Architecture

There is no unique architecture to allow PinS down to LPV minima, or for RNP APCH down to LPV minima.

The impacted systems are:
- The Flight Management system to integrate the RNP APCH capability,
- The display system to provide the data required by civil regulations,
- The Flight Control System, usually a 4-axis autopilot, in order to guide the helicopter along the path,
- The Helicopter Terrain Awareness System for alerting to excessive deviation with respect to the path.

For LNAV minima, a GPS as the positioning source is sufficient, and a single flight management system is acceptable.

For LPV, the GNSS must be a GPS augmented with the SBAS (Satellite Based Augmentation System) capability in accordance with the function and performance required in RTCA DO229 (). A TSO approval or equivalent will facilitate the certification activities when the equipment is integrated into the aircraft.

For the more stringent LPV minima, a single FMS, single GNSS may be possible, provided the adequate level of safety is demonstrated. In general this is achieved through dual GNSS installation.

The PinS operation relies on GNSS only, because the GNSS is the only affordable position source on helicopters. For LPV minima, the GPS with SBAS is the only position source which complies with precision and integrity requirements of this type of operation.

PinS are often combined with low-level routes because:
- This avoids interference with higher-altitude traffic,
- Helicopters are not pressurized,
- This limits the risk of icing,
- This avoids spending time in climb and descent.

Low-level routes, when defined in mountainous environments, degrade the reception of conventional ground navaids such as VOR or DME. In addition, in some airspace, for cost savings, there may be a reduction of the ground infrastructure.

To ensure a system which is robust to single computer failure (flight management or GNSS), dual systems are usually integrated.

A typical architecture is defined below in Figure 12:

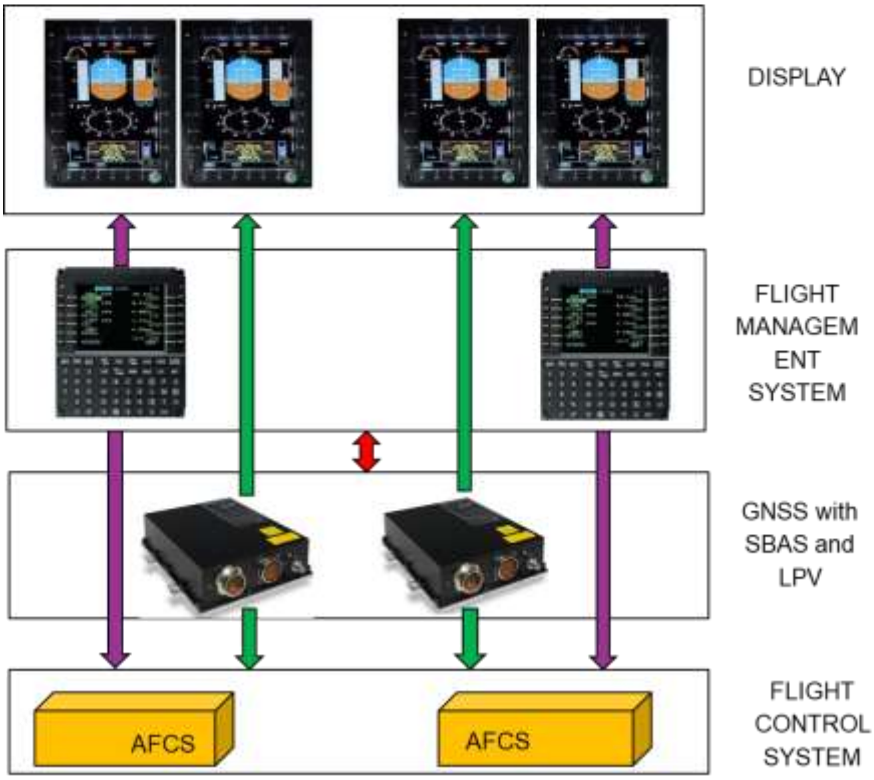

Figure 12: Typical system architecture for Helicopter PBN operations

Other solutions can be provided based on integrating a single FMS and single GNSS, but combined with an LPV monitor computer to provide an adequate level of safety. With such a solution, there is a limited impact on the interseat console especially for retrofit.

From LNAV to LPV cockpit

A LNAV capable cockpit is typically based on a single FMS, and a single GNSS for helicopter operations, mainly due to weight and cost savings, but also to limited space available on the interseat console. It is often without SBAS capability. Such a system provides horizontal guidance data only.

To integrate LPV capability, the changes are often:
- Integration of a dual system (Flight Management System, and GNSS, sometimes within the same equipment),
- Change of the GPS for a GPS with SBAS capability, compliant with TSO C145/TSO C146
- and integration of vertical data in the display, as well as the indication of the level of service,
- Unless the integration of the LPV function with the flight control system is performed as an ILS, sometimes called 'ILS-like', dedicated control laws, which consider the geometry of the path (especially the vertical path angle), are usually developed.

When the flight control system is modified with a dedicated law, it is possible to optimize the guidance law of the 4-axis autopilot compared to conventional ILS approach. This significantly contributes to maintaining adequate performance for steep approaches.

In a modern cockpit there is a HTAWS (Helicopter Terrain Awareness Warning System) which is already connected to the ILS, and in this case the HTAWS has to be integrated with the system providing LPV deviation.

An example of a display to comply with requirements, as defined by the regulations, is shown below on a “Helionix” display (Figure 13):

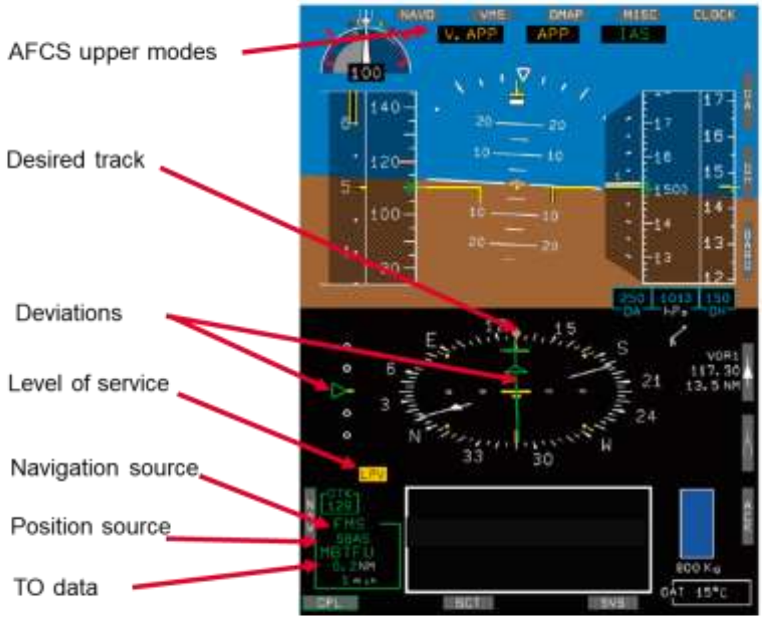

Figure 13: Display characteristics on Helionix

In a dual system, degradation will include loss of a positioning sensor (e.g. GNSS) or flight management system, discrepancy between sensors or flight management system, loss of synchronization between flight management system, degradation of level of service following a degradation of integrity. The figure below shows a degradation from LPV minima to LNAV minima following loss of integrity on the vertical axis: level of service indicated in amber before reversion to LNAV minima, loss of vertical scale, degradation of the vertical coupling indicated in amber

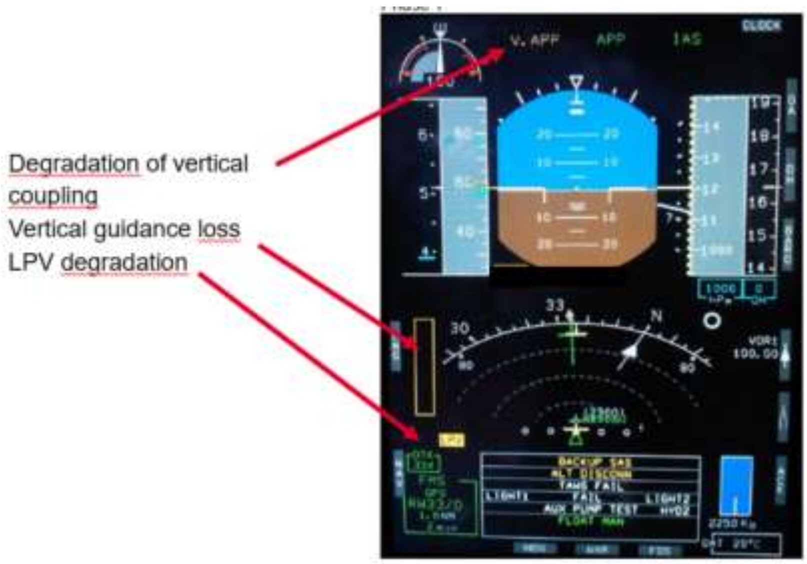

Figure 14: Level of service degradation

4. How to design and validate a PBN procedure

The deployment of helicopter PinS operations is a multi-player change and therefore requires coordination between different stakeholders (service providers, heliport/landing site operators and helicopter operators).

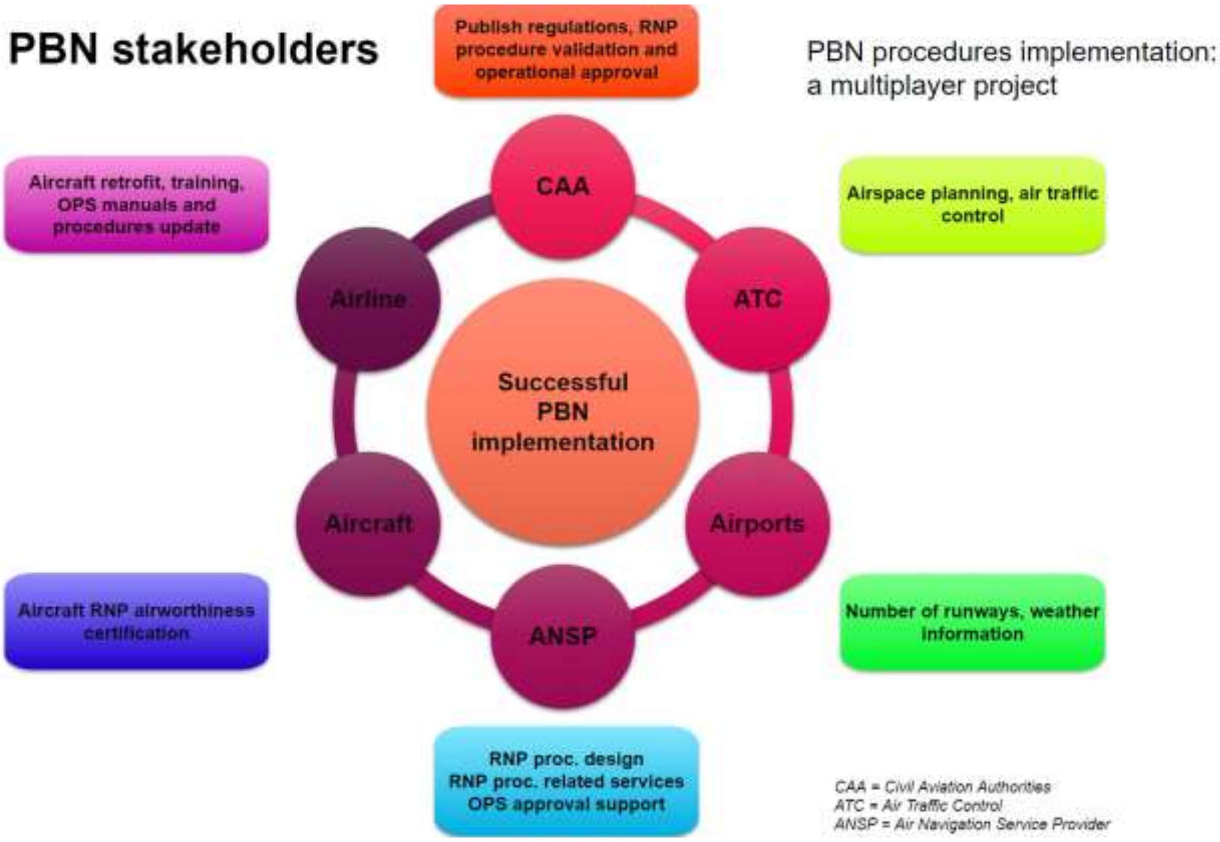

Figure 15: PBN stakeholders involved in procedure design

As per ICAO Doc 9992 (Manual on the use of PBN in Airspace design), the development and implementation of an airspace concept can be broken down into four main phases: **plan**, **design**, **validate** and **implement**.
Airspace redesign is usually initiated by an event which triggers an operational requirement. Such events are often categorized by one or more strategic objectives such as safety, capacity, flight efficiency, environmental mitigation or access.
There are two prerequisites for a successful airspace concept development:

- Comprehensive preparation: planning must take all aspects into account and must address all related stakeholder concerns,
- Iteration: airspace development is not a linear process, it can only result in a sound product through a series of reviews, validations and subsequent refinements.

This coordination is essential to ensure a safe deployment, and to face multiple challenges.
Challenges in technical design may include PBN procedure requirements, aircraft performance differences, and stakeholder needs.
Regarding procedure requirements, when coupled with local terrain, airspace and noise abatement constraints, it is possible that the procedures may be operationally challenging or unfeasible to implement, or may have high ceiling and visibility requirements.
Regarding aircraft performance, different aircraft and their FMSs can exhibit performance differences while flying the same procedure. Accounting for the breadth of performance differences in the design and evaluation of the procedure can be challenging.

Regarding stakeholder needs, achieving the benefits of the proposed procedures, while adjusting the design to meet the needs of all stakeholders without compromising the design objectives, can be challenging.

Challenges in the procedure development process are numerous and include the following key examples.
Firstly, it can be challenging to adequately define the design objectives, characterize the baseline operations and use of legacy procedures, and assess the benefits.
Secondly, given the breadth and potentially differing perspectives of the procedure design team members, conflicts and challenges may occur in coordination and execution during design and implementation of the procedures.

Thirdly, the validation and approval of the design and the procedures can be lengthy.
Indeed, the implementation of procedures is the responsibility of Contracting States. This means that the State authorities have the final responsibility for the procedures published within their territory. The FPD process may be carried out by States themselves or by delegation from States to third parties (Air Navigation Service providers (ANSPs), private companies such as NAVBLUE, another State, etc.). The Procedures for Air Navigation Services - Aircraft Operations (PANS-OPS, Doc 8168) requires that the State takes measures to control the quality of the process used to apply procedure design criteria. These measures must ensure the quality and safety of the procedure design product through review, verification, coordination and validation at appropriate points in the process, so that corrections can be made at the earliest opportunity.

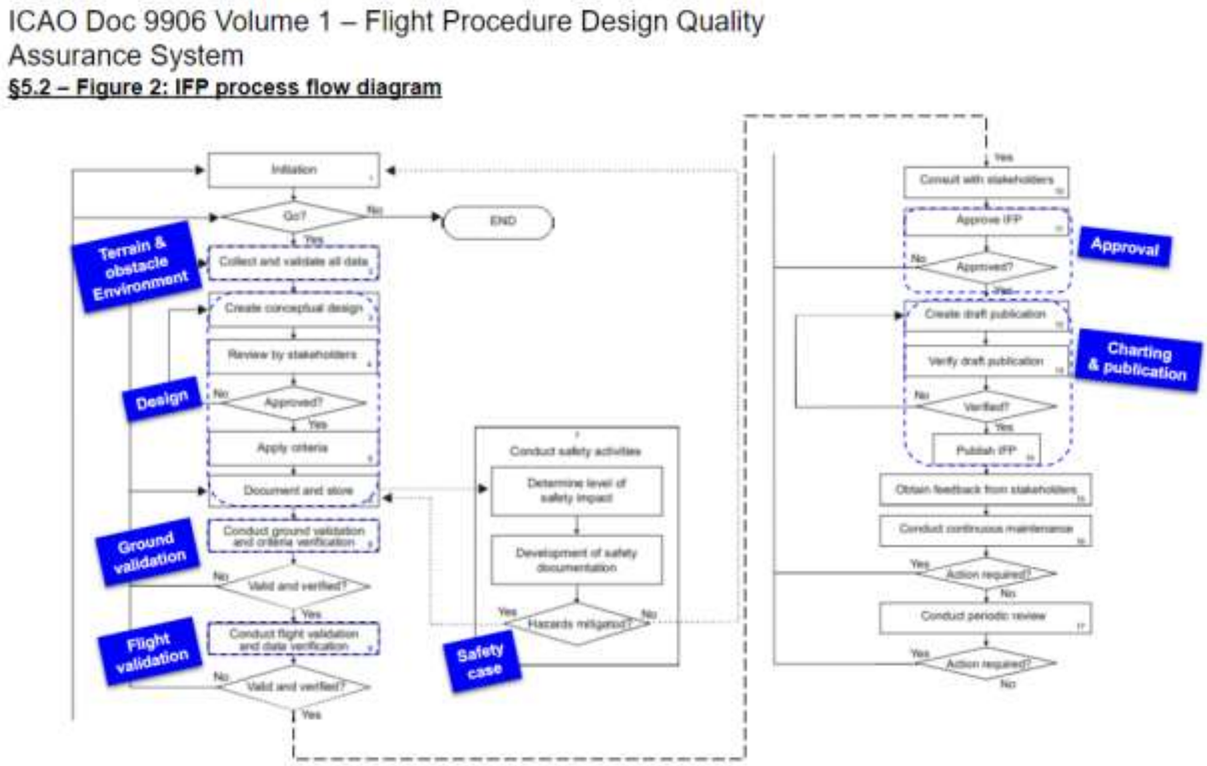

Figure 16: IFP process flow diagram

The development of an IFP (Instrument Flight Procedure) follows a series of steps from the origination of the data through survey to the final publication of the procedure and subsequent encoding of it for use in an airborne navigation database. There should be quality control procedures in place at each step to ensure that the necessary levels of accuracy and integrity are achieved and maintained.

Once the procedure has been approved and published, the process is not yet completed.

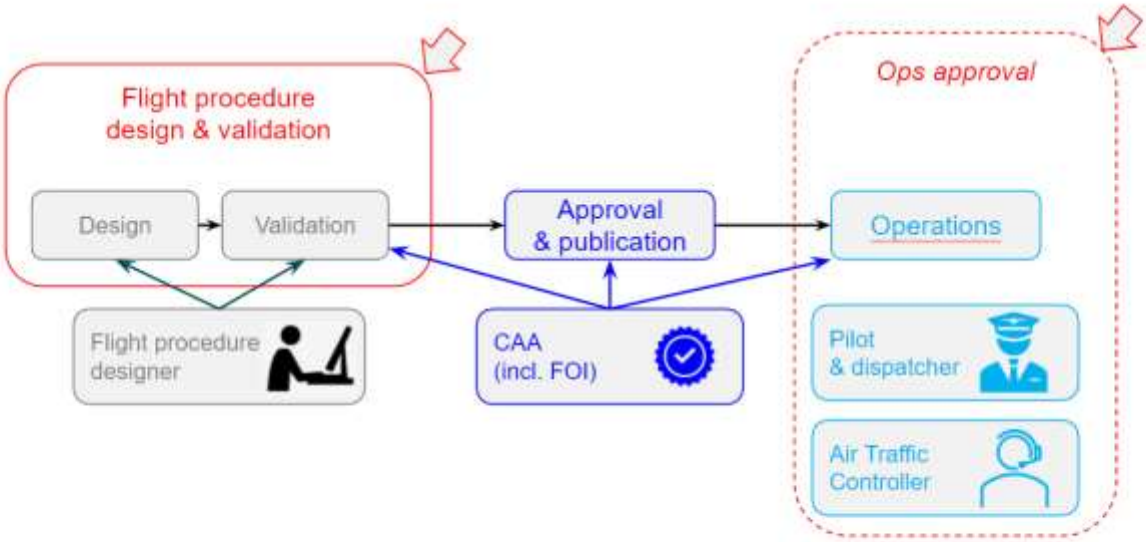

Figure 17: IFP validation and operations approval flow diagram

The PBN concept requires that the aircraft meets certain airworthiness certification standards, including the necessary navigation system performance and functionality, to be eligible for a particular application, and that **the operator** has **operational approval** from an appropriate regulatory body before the system can be used (according to European regulations, operational approval is required only for RNP AR and RNP 0.3 applications). A PBN navigation specification operational approval is an approval that authorizes an operator to carry out defined PBN operations with specific aircraft in designated airspace. The operational approval for an operator may be issued when the operator has demonstrated to the regulatory authority of the State of Registry/State of the Operator that the specific aircraft are in compliance with the relevant airworthiness standard and that the continued airworthiness and flight operations requirements are met.

Operational approval to RNP 0.3 for the crew is not covered under the standard IR PBN training, this is a 'special' process and it requires the crew to be specifically approved for the operation.

5. Executive summary

Controlled Flight into Terrain and Obstacle Strike remain frequent accident scenarios in rotorcraft operations. PinS and IFR low-level routes, with PBN as the enabler, are proven ways to avoid low-level flying in degraded visual environments or “scud running”, which is the prime cause of such accidents.
Dedicated helicopter procedures (low-level routes, Point In Space) as well as approach procedures considering the helicopter flight envelope facilitate helicopter operation in IFR, minimizing interaction with existing traffic for fixed-wing aircraft, and contribute significantly to the safety of flight minimizing risk of operation in marginal VMC conditions.

As a consequence, Airbus Helicopters and NAVBLUE will gladly support operators & authorities for the implementation of PinS and IFR low-level routes.
You can contact: airspace@navblue.aero

6. Glossary

AC	Advisory Circular
ATC	Air Traffic Control
ATM	Air Traffic Management
ATS	Air Traffic Services
CFIT	Controlled Flight Into Terrain
CRC	Cyclic Redundancy Check
CS	Certification Specification
CTR	Controlled Traffic Region
DME	Distance Measuring Equipment
EASA	European Union Aviation Safety Agency
EGNOS	European Geostationary Navigation Overlay Service
FAA	Federal Aviation Administration
FAF	Final Approach Fix
FAP	Final Approach Point
FAS DB	Final Approach Segment Data Block
FATO	Final Approach and Take-Off
FMS	Flight Management System
GNSS	Global Navigation Satellite System
HTAWS	Helicopter Terrain Awareness Warning System
IAF	Initial Approach Fix
ICAO	International Civil Aviation Organization
IDF	Initial Departure Fix
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
LNAV	Lateral Navigation
LPV	Localizer Performance with Vertical Guidance
MAPt	Missed Approach Point
MCA	Minimum Crossing Altitude
NAVAID	NAVigational Aids
NDB	Non-Directional Beacon or Navigation DataBase
Nm	Nautical Mile
OBPMA	On-Board Performance Monitoring & Alerting
OCH	Obstacle Clearance Height
OIS	Obstacle Identification Surface
PBN	Performance-Based Navigation
PinS	Point In Space
RAIM	Receiver Autonomous Integrity Monitoring
RNAV	aRea Navigation
RNP	Required Navigation Performance
SBAS	Satellite-Based Augmentation System
SID	Standard Instrument Departure
STAR	Standard Arrival
TMA	Terminal Maneuvering Area
TSE	Total System Error
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions
VNAV	Vertical Navigation
VOR	VHF Omnidirectional Range
VSDA	Visual Segment Descent Angle
WAAS	Wide Area Augmentation System
XTK	Cross-Track