

INTERNATIONAL CIVIL AVIATION ORGANIZATION



EUR RNP APCH Guidance Material
(EUR Doc 025)

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1. Introduction

1.1. ICAO is encouraging all States to implement RNP APCH procedures and requesting the publication of a PBN Implementation Plan through the ICAO Assembly Resolutions 36-23 and 37-11. This document has been developed in response to an increasing need for guidance on RNP APCH implementation that has been expressed in several forums.

1.2. This guidance is primarily intended for States in the ICAO European region who wish to implement RNP APCH operations. It describes the generic steps that an ANSP and/or Airport should undertake to introduce such operations together with the applicable standards and relevant documentation that is available. The guidance also addresses aircraft operators by including an overview of the available standards that can be used to obtain airworthiness certification and operational approval.

1.3. RNP AR APCH procedures are outside the scope of this document.

2. Glossary of Main Terms

2.1. **ABAS** - Aircraft-based augmentation system. An augmentation system that augments and/or integrates the information obtained from the other GNSS elements with information available on board the aircraft. (ICAO Annex 10). RAIM is a form of ABAS.

2.2. **APV Baro-VNAV** – RNP APCH down to LNAV/VNAV minima

2.3. **APV SBAS** – RNP APCH down to LPV minima

2.4. **Baro-VNAV** – Barometric vertical navigation (Baro-VNAV) is a navigation system that presents to the pilot computed vertical guidance referenced to a specified vertical path angle (VPA), nominally 3°. The computer-resolved vertical guidance is based on barometric altitude and is specified as a VPA from reference datum height (RDH). (PANS OPS)

2.5. **Basic GNSS** – Refers to core constellation augmented by ABAS. The term “Basic GNSS receiver” designates the GNSS avionics that at least meet the requirements for a GPS receiver as outlined in Annex 10, Volume I, and the specifications of RTCA/DO-208 or EUROCAE ED-72A, as amended by United States Federal Aviation Administration FAA TSO-C129A or European Aviation Safety Agency ETSO-C129A (or equivalent). (PANS OPS).

2.6. **CDFA** – CDFA is a technique for flying the final approach segment of an NPA as a continuous descent. The technique is consistent with stabilized approach procedures and has no level-off. A CDFA starts from an altitude/height at or above the FAF and proceeds to an altitude/height approximately 50 feet (15 meters) above the landing runway threshold or to a point where the flare manoeuvre should begin for the type of aircraft being flown. This definition is harmonized with the ICAO and the European Aviation Safety Agency (EASA).

2.7. **CRC** – Cyclic Redundancy Check

2.8. **DA/H** – Decision Altitude/Height, used in Precision and APV Approaches

2.9. **EGNOS** – The European Geostationary Navigation Overlay Service. This is the European Satellite Based Augmentation System (SBAS).

2.10. **EGNOS SoL** – The EGNOS Safety of Life Service is the Service offered to aviation users as described in the EGNOS Sol Service Definition Document issued by the European Commission. [20]

2.11. **ESSP** – European Satellite Services Provider is the EGNOS operator and Navigation Service Provider certified according to the SES regulation as an ANSP.

2.12. **Final approach segment (FAS) data block.** The APV database for SBAS includes a FAS Data Block. The FAS Data Block information is protected with high integrity using a cyclic redundancy check (CRC). (PANS OPS)

2.13. **GNSS** – Global Navigation Satellite System. GNSS is a generic term for all satellite navigation systems and their augmentations. GNSS includes GPS, ABAS, SBAS, GBAS, Galileo, Glonass, Compass

2.14. **GPS NPA** – An RNP APCH flown to LNAV minima. The term is also used in the ICAO classification of approaches.

2.15. **LNAV, LNAV/VNAV, LPV and LP** are different levels of approach service and are used to distinguish the various minima lines on the RNAV (GNSS) chart. The minima line to be used depends on the aircraft capability and approval.

2.16. **LNAV** – Lateral Navigation. The minima line on the chart for RNP Approaches without vertical guidance.

2.17. **LNAV/VNAV** – the minima line based on Baro-VNAV system performances that can be used by aircraft approved according to AMC 20-27 or equivalent. LNAV/VNAV minima can also be used by SBAS capable aircraft.

2.18. **LPV** – Localiser Performance with Vertical Guidance: the minima-line based on SBAS performances that can be used by aircraft approved according to AMC 20-28 or equivalent.

2.19. **LP Approach Procedures** - At some airports, it may not be possible to meet the requirements to publish an approach procedure with LPV vertical guidance. This may be due to: obstacles and terrain along the desired final approach path, airport infrastructure deficiencies, or the inability of SBAS to provide the desired availability of vertical guidance (i.e., an airport located on the fringe of the SBAS service area). When this occurs, a State may provide an LP approach procedure based on the lateral performance of SBAS. The LP approach procedure is a non-precision approach procedure with angular lateral guidance equivalent to a localizer approach. As a non-precision approach, an LP approach procedure provides lateral navigation guidance to a minimum descent altitude (MDA); however, the SBAS integration provides no vertical guidance. (Definition from ICAO PBN Manual)

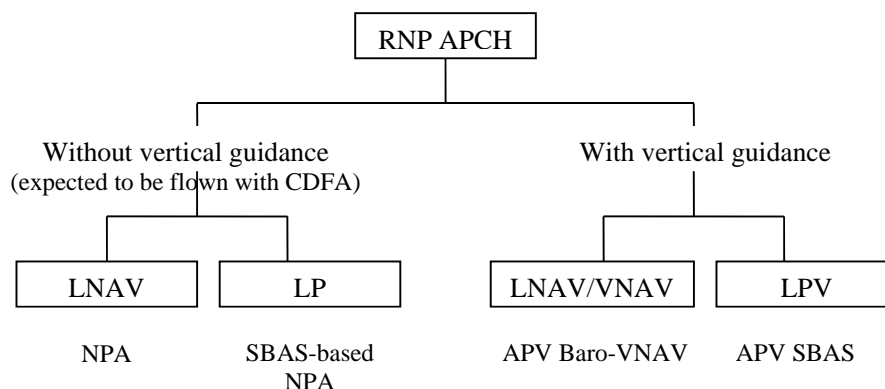
2.20. **MDA/H** – Minimum Descent Altitude/Height, used in a Non-precision Approach when not flown using the CDFA technique.

2.21. **NPA** – Non-Precision Approach

2.22. **PBN** – Performance-Based Navigation. The PBN concept specifies Navigation Specifications in terms of navigation system performance accuracy, integrity and continuity along with the functionality required onboard an aircraft for the proposed operations

2.23. **RNP APCH** – This is the terminology used in the ICAO PBN Manual [1] to describe the four approach types shown in Figure 1. Note that all these procedures are published on a chart with the title RNAV (GNSS).

Figure 1: The four types of RNP APCH described in the ICAO PBN Manual



2.24. **RNAV Approach** – This is a generic name for any kind of approach that is designed to be flown using the onboard area navigation system. It uses waypoints to describe the path to be flown instead of headings and radials to/from ground-based navigation aids. RNP APCH navigation specification is synonym of RNAV approach.

2.25. **RNP AR APCH** – An approach which always requires a specific operational approval (SPA). Such procedures are useful in particular environments rich in obstacles and dense terminal areas.

2.26. **RNAV** – Area Navigation

2.27. **RNP** – Required Navigation Performance

2.28. **SBAS** – Satellite-Based Augmentation System. This is a generic name for a system based on geostationary satellites and accompanying ground stations used for the augmentation of core constellation GNSS signals. The European SBAS is called EGNOS, the US version is called WAAS and there are also other SBASs in different regions of the World such as GAGAN in India and MSAS in Japan.

2.29. **SPA** – Specific operational approval required by EU-OPS, EASA-OPS or State rules on air operations for certain types of instrument navigation operations.

2.30. **VNAV** – Vertical Navigation

3. Applicable Standards and Documentation

1. ICAO, Performance-Based Navigation Manual, Volume II, Implementing RNAV and RNP (Doc 9613)
2. ICAO State Letter SP 65/4-10/53, Guidance material for the issuance of required navigation performance approach (RNP APCH) operational approval (23rd July 2010)
3. ICAO Assembly Resolutions A37-11 and A36-23
4. EUROCONTROL ESSIP Objectives, NAV10 in for period 2011-2015
5. ICAO Annex 14 – Aerodromes
6. Consistency of current ICAO material (Annexes and Manual) vs. APV operations (presented by France at ICAO NSP 2010, WG/WP64)
7. EU OPS 1 Subpart E All Weather Operations (EU OPS 1.430 Aerodrome Operating Minima, (d) Determination of RVR / CMV / Visibility Minima for Category I, APV and Non-Precision Approach operations, table 5)
8. ICAO, Doc 4444, Procedures for Air Navigation Services, Rules of the Air and Air Traffic Services (PANS-ATM)
9. EUROCONTROL MET Tool, <http://www.ecacnav.com/Tools/MET>
10. RNAV Approach Benefits Analysis V2.1, May 2009. Produced by Helios for EUROCONTROL.
11. ICAO, Doc 8168, Procedures for Air Navigation Services – Aircraft Operations (PANS OPS)
12. ICAO Annex 4 – Charting
13. ICAO Doc 9906 – Quality Assurance Manual for Procedure Design
14. ICAO Annex 15 – Aeronautical Information Service
15. ICAO Doc 9635 Manual of All Weather Operations
16. EUROCONTROL Tool for FAS DB <http://fas.ecacnav.com>
17. EUROCONTROL Tool for GPS outage prediction Augur, <http://augur.ecacnav.com>
18. RNP APCH with Baro VNAV, Safety Assessment Report , Eurocontrol 2010.
19. EUROCONTROL Airspace Concept Handbook for the Implementation of Performance Based Navigation (PBN) Edition 2.0
20. EGNOS Safety of Life Service Definition Document (EGNOS SoL SDD), 2nd March 2011, http://www.essp-sas.eu/service_definition_documents
21. EASA AMC 20-27 Airworthiness Approval and Operational Criteria for RNP APPROACH (RNP APCH) Operations Including APV Baro-VNAV Operations
22. EASA AMC 20-28 Airworthiness Approval and Operational Criteria for RNP APPROACH (RNP APCH) Operation to LPV minima using SBAS

4. PART A – INTRODUCTION TO RNP APCH OPERATIONS

4.1. Background Information

4.1.1. The widespread availability of high-performance RNAV systems on all types of aircraft and in particular the introduction of GNSS has made it possible to use area navigation in the approach phase of flight. Safety is improved by providing pilots with better situational awareness than on conventional Non-Precision Approaches (NPA), thereby reducing the risk of controlled flight into terrain (CFIT). Better access can also be provided to runways that are not equipped with precision approach and landing systems.

This guidance material is mainly intended for States in the ICAO European Region who wish to implement RNP APCH operations. It describes the steps that an ANSP and/or Airport should undertake to implement such operations and indicates the applicable standards and relevant documentation that is available. Finally, it provides guidance to air operators as to how to obtain approval for such operations.

4.1.2. Instrument Approach Procedures

Traditionally, there have been two types of Instrument Approach Procedure:

- Precision Approach (PA) uses for the final approach segment an instrument landing system (e.g. ILS, GBAS, MLS) which provides both lateral and vertical guidance on a geometrically defined continuous descent path.
- Non-Precision Approach (NPA) uses for the final approach segment, conventional navigation aids (e.g. NDB, VOR, DME) or basic GNSS (e.g. GPS) and provide only lateral guidance along the final approach segment.

4.1.3. Studies have shown that the risk of controlled flight into terrain (CFIT) on non-precision approaches could be significantly reduced. An improvement that gives pilots better situational awareness on NPA is to fly them using the RNAV capability of the aircraft. The RNAV system can be used for approach phase of flight, provided RNAV approach procedures are designed and published. RNAV approaches are described by a series of waypoints, legs, altitude and speed constraints published and stored in the onboard navigation database.

4.1.4. GNSS-based RNAV capabilities were initially used to fly NPA procedures. These procedures are published with a Minimum Descent Altitude/Height (MDA/H), as with any conventional NPA procedure. The MDA/H is indicated in the LNAV minima line on the RNAV (GNSS) instrument approach chart.

4.1.5. No modifications to the cockpit instruments (e.g. conventional Course Deviation Indicator – CDI, or electronic displays) are in principle necessary to use RNP APCH on-board.

4.1.6. The level-off or dive and drive descent technique used along the conventional final approach segment in NPA procedures for flying NPAs containing step-down fixes, which is prone to error, should also be removed from the final approach segment. Operators are being encouraged¹ to fly these procedures using the Continuous Descent Final Approach (CDFA) flying technique. This can be based on a manual calculation of the required rate of descent or it can make use of the VNAV guidance function that is available on many aircraft. The design of a NPA procedure is made according to a single set of design criteria in ICAO PANS-OPS and

¹ This is even mandatory for public transport and general aviation (heavy aircraft only)

is not dependent on the flying technique. Charts include the nominal descent gradient. The minima are calculated in accordance with Appendix 1 (New) of EU OPS 1.430. As CDFA is the recommended technique, the document provides values to be added to RVR minima in case CDFA is not used.

4.2. Approaches with vertical guidance (APV)

4.2.1. In addition to lateral RNAV capabilities, modern multi-sensor RNAV systems provide a VNAV function which allows a vertical path to be flown with a constant rate of descent based on the Barometric altimeter, or on GPS augmented SBAS position. Provision of both lateral and vertical guidance may also be based on LPV capability of an aircraft.

4.2.2. RNAV approaches using both lateral and vertical guidance are defined by ICAO in PANS OPS (Doc 8168) as Approach with Vertical Guidance (APV). The vertical guidance is provided only along the final segment whatever onboard system is used.

4.2.3. The RNAV procedures using Barometric VNAV for vertical guidance are called APV Baro VNAV and are flown to a Decision Altitude/Height indicated in the LNAV/VNAV minima line on the chart. Aircraft equipped with SBAS systems can also fly procedures designed for APV Baro VNAV if the State publishing the procedure permits it.

4.2.4. The RNAV procedures using SBAS for vertical guidance are called APV SBAS procedures and are flown to a Decision Altitude/Height indicated in the LPV minima line on the chart.

4.3. Approaches and the PBN concept

4.3.1. ICAO's PBN concept was published in the ICAO PBN Manual (Doc 9613) in 2007 replacing the previous RNP Concept and RNP Manual. The PBN Concept aims to streamline RNAV and RNP applications on a global basis by reducing the number of navigation specifications in use worldwide and thus enhancing safety, improving interoperability and reducing costs for operators. To these ends, the PBN manual includes a limited set of PBN specifications for worldwide use in different phases of flight.

4.3.2. For intermediate, final approach, initial and intermediate phases of missed approach, the ICAO PBN Manual specifies RNP APCH navigation specifications which are to be found on PBN, Volume II, Part C, Chapter 5 [1]. Initial approach segment and final missed approach segments can be supported either by RNP APCH or by RNAV1.

4.3.3. RNP APCH procedures are published on charts with the title RNAV (GNSS) RWY XX. That is the reason why they are referred to so far as RNAV approaches. These approach charts can have several minima lines depending on the type of final segment defined with the RNP APCH. The table below provides cross reference between PANS-OPS and PBN terminology.

Table 1: RNP APCH terminology as per PBN Manual - ICAO State Letter [2]

PANS-OPS Terminology	PBN Terminology	Chart Minima	Minimum Sensor
NPA	RNP APCH down to	LNAV (MDA)	Basic GNSS ²
APV Baro-VNAV	RNP APCH down to	LNAV/VNAV (DA)	Basic GNSS + Baro-VNAV
-No criteria available	RNP APCH down to	LP (MDA)	SBAS
APV SBAS	RNP APCH down to	LPV (DA)	SBAS

4.3.4. An example of an RNAV Approach chart containing the different minima lines is provided in the Activity 15 concerning procedure publication.

4.3.5. A common misunderstanding arises from the fact that the term RNAV is used to refer to a navigation capability as well as to operations and chart naming. Approaches with or without vertical guidance down to LNAV, LNAV/VNAV or LPV minima are a sub-category of RNAV approaches and as such published on charts with a title in the form RNAV (GNSS) RWY XX. The Navigation specification for these approaches is RNP APCH, as described in the ICAO PBN Manual [1]. According to PANS ATM [8] section 12.3, the term RNAV is currently used in approach clearance phraseology. In this guidance PBN Manual terminology will be used wherever possible, referring to the above procedures as RNP APCH and specifying the minima line to be used for a specific operation.

4.3.6. Note that RNP APCH procedures, as defined in the PBN Manual, have already been implemented in a number of States. Although not all standardisation documents are using the same terminology, sufficient elements can be found in the standards to support RNP APCH implementation. This guidance provides a list of applicable standards and documents and the glossary and the table above can be used as a cross reference to understand the terminology.

4.4. Provision of vertical guidance

4.4.1. The important distinction between the different types of RNP APCH operations is the provision of vertical guidance. RNP APCH to LNAV and LP minima include only lateral guidance and are published with a MDA while RNP APCH procedures with vertical guidance (APV) are published with a DA, which may be lower than the MDA thus potentially increasing airport accessibility. In addition, the provision of vertical guidance improves pilot situational awareness, thus improving safety.

4.4.2. The procedure design criteria and the construction of a vertical profile are different for the different RNP APCH operations and should be given particular consideration. For RNP APCH procedures to LNAV and LP minima, only lateral guidance is provided.

4.4.3. For RNP APCH to LNAV/VNAV minima, vertical guidance is provided in addition to the lateral guidance same as for LNAV-only. The theoretical vertical descent profile is defined by a geometrical path with fixed flight path angle. The vertical path angle is computed between 50ft above the runway threshold and a final capture point which corresponds to the location of the FAF associated with the NPA RNP APCH even though the WP associated with the FAF of the NPA RNP APCH is never used on board to start the final

² Basic GNSS refers to core constellation combined with ABAS.

descent for the APV Baro-VNAV. The final path starts when the aircraft intersects the vertical final guidance. But this point of intersection is very close to FAF of NPA RNP APCH. Vertical deviations are usually linear. Given that the vertical path is based on barometric inputs, it is very important that the correct local pressure setting (QNH) is entered into the system. The final descent is also influenced by temperature: temperature limits³ are published on the chart.

4.4.4. RNP APCH to LPV minima is based on GNSS core constellation and SBAS. The vertical guidance is angular and the final approach segment profile is defined in the Final Approach Segment Data Block (FAS DB). The vertical path angle is defined (not computed) and published in degrees (mainly 3°). Integrity of the FAS DB data is maintained through the use of a CRC.

³ Currently only the lower temperature value is published on the chart.

5. PART B – GUIDANCE ON THE IMPLEMENTATION OF RNP APCH

5.1. General

5.1.1. Implementation of RNP APCH operations is a complex process covering a wide range of actors. In the following description the necessary activities are divided into 2 processes in line with ICAO PBN implementation methodology provided in the ICAO PBN manual [1]. This methodology breaks the implementation process into a number of individual steps. In this document a number of Activities are described that need to take place in order to achieve the various steps of the process. These activities are presented, as far as possible, in a chronological order.

5.1.2. In Process 1, the objective is to gather information so that a decision can be taken on what type of RNP APCH should be implemented and where. Process 2 will consist of the tasks needed to perform the actual implementation. For information, a mapping between Activities described in the current document and the Steps described in the ICAO PBN implementation methodology is provided in Annex 1. General implementation considerations are provided here and States should feel free to adapt them to their specific situation.

5.2. Process 1: Agreeing the operational requirement and building the implementation plan

5.2.1. General

5.2.1.1. The need to implement RNP APCH operations should be discussed and clarified. At this stage, the reasons for the deployment of RNP APCH are being considered.

5.2.1.2. Process 1 consists then of all activities required to take a decision on what type of RNP APCH should be implemented and at which locations. The output of this process is a decision to implement RNP approaches and a deployment strategy.

5.2.1.3. In case the implementation plan is developed at State level, the following activities will consist of selecting a pool of potential airports and selecting the preferred implementation locations. This activity must be performed in close co-operation with all the stakeholders such as Aircraft Operators, ANSPs, Regulators and Airports in order to identify the most suitable airports for RNP APCH implementation and the deployment sequence.

5.2.1.4. Alternatively, the implementation plan can be developed by an ANSP or at the level of an individual Airport. This would be mainly due to Aircraft Operator request. In this case, other stakeholders such as the Regulator need to be involved as soon as possible in the RNP APCH implementation processes.

5.2.2. Activity 1: The background to RNP APCH implementation

5.2.2.1. Implementation of RNP APCH procedures may be triggered by a number of different factors, which can depend on the organisational and institutional arrangements. These inputs may include, though are not limited to, the following:

5.2.2.2. ICAO Assembly Resolutions A37-11 [3]

5.2.2.2.1. The implementation of RNP APCH procedures with vertical guidance (APV) was primarily encouraged by ICAO Assembly Resolution 36-23 which urges the States to implement APV procedures to all instrument runway ends by 2016, either as primary or as backup approach procedures. RNP APCH to LNAV/VNAV and RNP APCH to LPV minima were the two options to fulfil the resolution. But the resolution A36-23 was updated at the 37th Assembly of ICAO, and resolution A37-11 (supersedes A36-23) now presents RNP APCH to LNAV minima as an acceptable alternative to APV in places where APV implementation is not possible or does not make sense as no aircraft are suitably equipped for APV operations. RNP APCH implementation is part of the resolution for ICAO PBN deployment, the main objective of which is to improve safety.

5.2.2.2.2. The executive part of the resolution A37-11 states:

[...]The Assembly:

1. Urges all States to implement RNAV and RNP air traffic services (ATS) routes and approach procedures in accordance with the ICAO PBN concept laid down in the Performance-based Navigation (PBN) Manual (Doc 9613);

2. Resolves that:

a) States complete a PBN implementation plan as a matter of urgency to achieve:

1) implementation of RNAV and RNP operations (where required) for en route and terminal areas according to established timelines and intermediate milestones; and

2) implementation of approach procedures with vertical guidance (APV) (Baro-VNAV and/or augmented GNSS), including LNAV only minima for all instrument runway ends, either as the primary approach or as a back-up for precision approaches by 2016 with intermediate milestones as follows: 30 per cent by 2010, 70 per cent by 2014; and

3) implementation of straight-in LNAV only procedures, as an exception to 2) above, for instrument runways at aerodromes where there is no local altimeter setting available and where there are no aircraft suitably equipped for APV operations with a maximum certificated take-off mass of 5 700 kg or more;

b) ICAO develop a coordinated action plan to assist States in the implementation of PBN and to ensure development and/or maintenance of globally harmonized SARPs, Procedures for Air Navigation Services (PANS) and guidance material including a global harmonized safety assessment methodology to keep pace with operational demands;

3. Urges that States include in their PBN implementation plan provisions for implementation of approach procedures with vertical guidance (APV) to all runway end serving aircraft with a maximum certificated take-off mass of 5 700 kg or more, according to established timelines and intermediate milestones;

4. Instructs the Council to provide a progress report on PBN implementation to the next ordinary session of the Assembly, as necessary;

5. Requests the Planning and Implementation Regional Groups (PIRGs) to include in their work programme the review of status of implementation of PBN by States according to the defined implementation plans and report annually to ICAO any deficiencies that may occur; and

6. Declares that this resolution supersedes Resolution A36-23. [...]

5.2.2.3. *Strategic objectives (e.g. safety, accessibility)*

5.2.2.3.1. RNP APCH has the potential to provide better minima than conventional Non-Precision Approach. Consequently, better airport accessibility can be achieved at those airports without precision approach capability, as well as at airports where precision approach aid is out of service (APV operation back-up solution in case of ILS outages).

5.2.2.3.2. Additionally, RNP APCH also brings improved situational awareness for the pilots in both the horizontal and vertical domain (in the case of APV), as well as the means to perform a stabilised approach, both of which contribute to improve safety.

5.2.2.3.3. Those two issues are often identified as strategic objectives for airports in locations with challenging terrain and climate.

5.2.2.4. Aircraft operator requests

5.2.2.4.1. With the widespread availability of GNSS-based RNAV and VNAV capability on many types of aircraft, operators may want to encourage RNP Approaches to be published so that they might benefit from these onboard capabilities. The operators could be motivated by better airport accessibility or improved safety.

5.2.2.5. PBN implementation plans and airspace concept

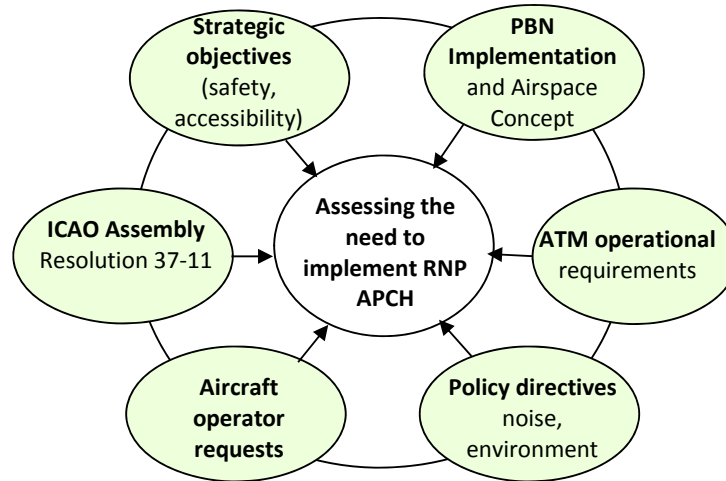
5.2.2.5.1. States may have already identified the need for RNP APCH implementation through the publication of a PBN implementation plan or through the development of a PBN compliant Airspace Concept. The PBN Manual introduces the Airspace Concept as a formal way of setting strategic objectives to be satisfied by selected operations within an airspace. Airspace changes are triggered by operational requirements such as for example addition of new runways, need to reduce aircraft noise over a residential area or improve airport accessibility.

5.2.2.6. ATM operational requirements

5.2.2.6.1. In Europe, the future ATM concept is described in the European ATM Master Plan and SESAR ATM Concept for 2020+. Approach Procedures with Vertical Guidance are part of the near term Operational Improvement Steps, Enhancing Terminal Area, as identified by the European ATM Master Plan and Work Program. (<http://www.atmmasterplan.eu>). The key performance areas of RNP operations identified in the master plan are capacity, environmental sustainability, cost effectiveness, capacity and safety.

5.2.2.7. Environmental policy directives

5.2.2.7.1. Potential policy directives for noise and environment demanding changes to arrival and departure routes may stimulate the need to implement RNP APCH operations.

Figure 2: Assessing the need for RNP APCH implementation

5.2.2.7.2. Once the potential benefits are identified and agreed among all the stakeholders, there should be a high level consensus around the decision to implement RNP APCH operations. This sets the scene for Process 1. At the same time, the actors need to comply with the applicable regulations in all areas of their activities. An additional reason to implement could be if it were required by a regional PBN implementing rule.

5.2.2.8. The European Regulatory Framework

5.2.2.8.1. There are several aspects of the RNP APCH implementation that are covered by regulatory oversight. The most well known is the aircraft certification and operational approval. In the EU area this will be performed under EASA rules. However, the implementation of RNP APCH procedures by an air navigation service provider is also subject to regulatory approvals. The regulatory oversight of the ANSP is currently performed by the Civil Aviation Authorities within each State. A framework and requirements on the quality of aeronautical data and aeronautical information for the single European sky is provided by EU Regulation 73/2010. In the EU area, due to the Single European Sky (SES) and in particular the EASA Basic Regulation (216/2008) the division of responsibilities between National authorities and EASA is currently evolving.

5.2.2.8.2. In order to implement RNP APCH procedures all constituents in the area regulated by EASA, products, operations and services will need to be under the responsibility of a clearly identified organisation. This includes:

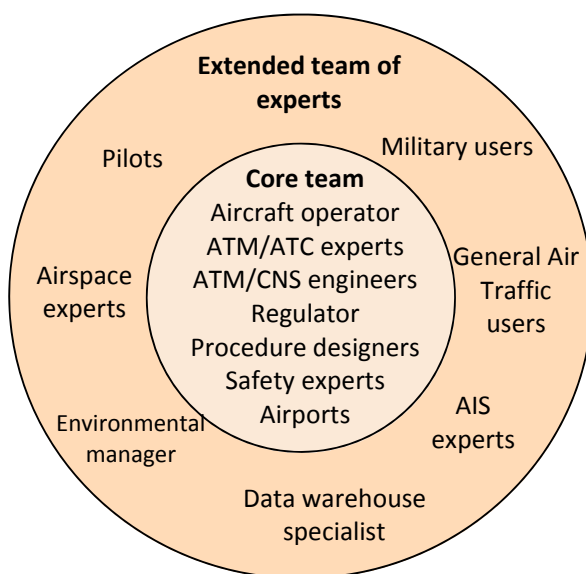
- Navigation Service Providers who provide radio-navigation signals.
- Aircraft and avionics manufacturers
- Aircraft operators
- Aerodrome operators
- Providers of Air Traffic Services
- Airspace/flight procedures designers
- AIS Service Providers
- Data suppliers

- Avionics Integrators

5.2.3. Activity 2: Create the implementation project team

5.2.3.1. A multi-disciplinary team is needed to ensure all necessary aspects of the implementation of RNP APCH procedures are recognised and adequately addressed, whether they are intended for a State, a set of airports or a single airport. The team composition may vary in different States, but principally, there should be a core team which can be extended on an “as needed” basis to include experts in particular domains as the implementation progresses.

Figure 3: Establish a national RNP APCH implementation team



5.2.3.2. Depending on arrangements in different States, implementation of RNP APCH operations may be initiated by different stakeholders, namely Aviation Authorities, ANSPs, or Airport operators. Regardless of which stakeholder is the initiator, they will all need to co-operate to ensure a smooth implementation and subsequent operation.

5.2.3.3. ANSPs, whether they provide a service for a country or a specific airport, are recognised to be the key actor who will drive the implementation of the change.

5.2.4. Activity 3: Agree project objectives, scope and timescale

5.2.4.1. Once the implementation team has been established, it needs to define the objectives, scope and resources for the team to build the implementation plan.

5.2.4.2. The timing for preparation of this plan may not be compatible with the objectives set in the ICAO resolution, but the priority should be put into enabling the first implementation (see Process 2) as soon as possible in order to gain the necessary experience.

5.2.4.3. If the RNP APCH implementation is made in the frame of an airspace concept development, a sample estimation of project timescale available in the EUROCONTROL Airspace Concept Handbook for the implementation of PBN [19] on page 33 may be a helpful initial reference.

5.2.5. Activity 4: Survey of candidate airports

5.2.5.1. When implementation of RNP APCH is planned on a national basis, or for a group of airports, a survey of airports should be performed. According to Assembly resolution A37-11, RNP APCH should be implemented to all “instrument runway ends” “serving aircraft with a maximum certificated take-off mass of 5 700 kg or more”.

5.2.5.2. As a first step, one or two candidate airports can be identified to be the first implementation locations. This will allow the national team to exercise all the necessary processes and gather the lessons learned before implementation on a wider scale.

5.2.5.3. Implementation at non-instrument runway ends is not currently envisaged by the international standards. First implementations should therefore take place at runways that already have an instrument approach procedure.

5.2.6. Activity 5: Assessment of Airport Capabilities

5.2.6.1. General

5.2.6.1.1. The capabilities of each of the airports chosen in the previous activity need to be assessed to determine whether RNP APCH operations can be implemented there, and if not, what modifications should be performed to enable the implementation.

5.2.6.1.2. The assessment should address the following domains:

5.2.6.2. Aerodrome infrastructure assessment

5.2.6.2.1. An assessment of the aerodrome infrastructure should be performed in order to determine the type of runways available on the airports of interest. Only instrument runways should be considered, and the type of instrument runway (non-precision or precision as defined in ICAO Annex 14) will impact the DA/H that can be achieved.

5.2.6.2.2. APVs are neither NPA nor PA, however the following principle applies according to ICAO PANS-OPS [11]

- For RNP APCH to LNAV/VNAV or LPV to a non-precision approach runway the DH shall not be below 300 ft.
- For RNP APCH to LNAV/VNAV or LPV to a precision approach runway a DH below 300 ft is permitted.

5.2.6.2.3. Applicable aerodrome operating minima may be found in the EU OPS 1.430 Appendix 1 (New). Those minima are also expected to be addressed in the future ICAO All Weather Operations Manual [15].

5.2.6.3. Meteorological data

5.2.6.3.1. The project team may want to collect data on the meteorological conditions such as wind statistics, cloud ceiling and RVR per runway end. This data can be used as an input to estimating the benefits in terms of improved runway accessibility. Indeed, the potential for lower minima with RNP APCH allows a better runway use in case of bad weather. For more details about benefit assessment please refer to Activity 8.

5.2.6.4. GNSS infrastructure

5.2.6.4.1. All RNP APCH operations rely on the use of Basic GNSS and the appropriate authority needs to agree to the use of GNSS in their airspace.

5.2.6.4.2. APV procedures flown to LPV minima rely on the use of GPS augmented by SBAS. The European Geostationary Navigation Overlay Service (EGNOS) is the regional SBAS. As EGNOS is a Pan-European Service used by aircraft and ANSPs and provided by an organisation established in the territory of the EU Member States, it is subject to the SES Regulations. Article 7 of Regulation (EC) 550/2004 referred to as the service provision regulation requires that providers of air navigation services are subject to certification. The common requirements for the provision of Air Navigation Services are described in Regulation (EC) 2096/2005. The application for certification must be made to the NSA of the Member State where the applicant has its principle place of operation.

5.2.6.4.3. The EGNOS service is provided by the European Satellite Services Provider (ESSP) whose headquarters is in Toulouse, France. It is therefore the French NSA that provided the ESSP with certification as an Air Navigation Service Provider on the 12th July 2010. The EGNOS Safety of Life (SoL) service commissioning took place on 2 March 2011. The EGNOS SoL is provided free of direct user charges.

5.2.6.4.4. After approval as a provider of air navigation services the ESSP was then required to submit a Declaration of Verification (DoV) for the system as required by Regulation (EC) 552/2004, often referred to as the Interoperability Regulation. The objective

of this declaration, also to the French NSA, is to confirm compliance with the Essential Requirements described in this regulation and to demonstrate compliance with the Standards and Recommended Practices (SARPs) in ICAO Annex 10. The DoV was submitted in July 2010 together with a supporting technical file.

5.2.6.4.5. With the changing role of EASA with Regulation (EC) 1108/2009 where their responsibilities will be extended to cover Aerodromes, Air Traffic Management and Air Navigation Services it is anticipated that the competent authority for safety oversight of EGNOS will transfer from the French NSA to EASA

5.2.6.4.6. APV procedures flown to LPV minima rely on the use of EGNOS SoL service. An ANSP implementing LPV is required by its State Civil Aviation Authority to have a working agreement with the EGNOS service provider. (For the EU States EC Regulation No 550-2004 Article 10 is applicable).

5.2.6.4.7. In case implementation of RNP APCH to LPV minima is planned, an assessment should be made to confirm if suitable EGNOS service is available at the aerodrome concerned. EGNOS coverage is described in the Service Definition Document (SDD) [20] available on the ESSP web site (<http://www.essp-sas.eu>).

5.2.6.4.8. According to ICAO recommendations, a legal recording mechanism should be put in place for any navigation system to be used in operations. This recommendation applies to GNSS. The archived data will be useful in the context of post accident/incident investigations. ANSPs or States do not necessarily have to set up their own recording system; they can have agreements with other parties to provide them with the necessary data (e.g. IGS for GPS or ESSP for EGNOS).

5.2.6.4.9. Concerning the availability of a real-time monitoring for GNSS systems, this is not considered as a requirement for RNP APCH Implementation. Indeed the performance observed on the ground with a receiver is not likely to be representative of the performance experienced onboard approaching aircraft: with PBN there is no longer a direct link between navigation systems on the ground (and in space) and the aircraft capability to perform an operation. In such conditions, real-time GNSS system status information is not useful for operations.

5.2.6.4.10. Moreover, in the case of RNP APCH, ATC will not be aware of the type of minima an aircraft will fly to (approach clearance is according to approach name - RNAV – and not to the type of minima). An aircraft will follow the same lateral path whether performing an approach down to LNAV, LNAV/VNAV or LPV minima available on the same chart.

5.2.6.4.11. A signal availability and spectrum check should be performed once as a pre-implementation step at the intended location, but a real time GNSS signal monitoring is not required. Integrity is monitored onboard the aircraft. More details on this subject are available in ICAO annex 10.

5.2.6.5. Other infrastructure

5.2.6.5.1. RNP APCH operations are based upon GNSS including the missed approach segment. Nevertheless, if required by the local safety assessment, some conventional nav aids (VOR, DME, NDB) can be locally maintained.

5.2.6.5.2. No specific communication and surveillance requirements are identified for RNP APCH implementation.

5.2.6.5.3. A priori, RNP APCH can be implemented in Radar and Non-Radar environment. The availability of a local ATC service is also not a requirement. This should be verified throughout the local safety assessment to be performed in the scope of Process 2.

5.2.6.5.4. The availability of a local QNH is a requirement for the publication of RNP APCH to LNAV/VNAV minima. Remote QNH is acceptable in the case of RNP APCH to LNAV minima and this is accounted for in the procedure design. . Remote QNH for APV procedures down to LPV minima is under consideration by the ICAO IFPP.

5.2.6.6. Achievable minima estimation

5.2.6.6.1. The project team can assess the minima available on the runways of interest prior to a decision to implement an RNP APCH. This will be useful in future steps to determine the minima reduction enabled by RNP APCH, and consequently to estimate the airport accessibility gain provided by the implementation of the procedure (see Activity 8).

5.2.6.6.2. EUROCONTROL has developed a tool called Minima Estimator Tool (MET) which estimates minima for all types of RNP APCH (except LP) accounting for the obstacle environment data and applying ICAO PANS OPS criteria. The MET tool is not a procedure design tool but an estimator tool which helps in a first assessment of the type of RNP APCH that would bring improved minima [9].

5.2.6.7. Integration of the new procedure into the terminal area

5.2.6.7.1. An initial airspace analysis should be made in order to assess the impact that implementation of RNP APCH would have on departure and arrival routes.

5.2.7. Activity 6: Survey of Traffic Characteristics and Aircraft Operators

5.2.7.1. Survey of traffic characteristics

5.2.7.1.1. It should be noted that not all RNP APCH types are of interest to all categories of airspace users. For instance RNP APCH operations based on Baro-VNAV are more likely to be the preferred option for commercial air transport operators whose aircraft are more likely to be equipped with barometric VNAV functions. RNP APCH operations based on SBAS may be the preferred option for regional operators and general aviation where VNAV capability based on barometric altimetry is not available. Consequently, the type of aircraft flying to and from an airport will influence the decision to implement one or another type of RNP APCH. If a mixture of traffic uses the airport it is recommended to implement an RNP APCH procedure with all three minima lines (LNAV, LNAV/VNAV and LPV.) The cost of designing and publishing several or all types of minima at a time will be lower than the sum of costs for the design and publication of the different minima one after the other.

5.2.7.1.2. In certain cases, the team must work with an estimation of a future traffic sample, for example, if the approaches are planned to be implemented at a new airport or where significant changes in the airspace concept are planned.

5.2.7.2. Survey of Aircraft Operators

5.2.7.2.1. The RNP APCH implementation process should be conducted in close co-operation with Aircraft Operators. It is very important to collect information regarding current and projected RNAV capabilities onboard the aircraft operating at the airport of interest, through a survey of Aircraft Operators. The survey should also include questions regarding the Aircraft Operators preferred approach operations.

5.2.7.2.2. Information should be collected regarding the following:

- aircraft equipment and navigation capabilities
- airworthiness and operational approval
- current experience with RNP APCH procedures
- operator requirements and preferences for RNP APCH procedures
- plans in terms of future equipage and operational approval

5.2.7.2.3. As several terminologies have proliferated around the use of RNAV and GNSS equipment and operations, it is suggested to use simple and straightforward questions to operators. If possible, provide an introduction section before the questions introducing RNAV approaches in order to avoid ambiguity.

5.2.7.2.4. Some sample questions may be:

- Please list the types of aircraft that are being operated.
- Do you have certified GPS receivers onboard the aircraft? If yes, please list for each type of aircraft the kind of the GPS receiver (e.g. TSO-C129a, TSO-C145a, TSO-146a) installed onboard.
- Does the aircraft have an RNAV or RNP capability onboard? For what phase of flight?
- Does the aircraft have Baro-VNAV capability onboard?
- Does the aircraft have SBAS and LPV capability onboard?
- Does the aircraft have an **airworthiness approval** for the use of GPS and/or EGNOS in the approach phase of flight? If yes, which type of operation (among different types of RNP APCHs)?
- Does the operator hold an **operational approval** for the use of GPS and/or EGNOS in the approach phase of flight? If yes, which type of operation (among different types of RNP APCHs)?
- Does the operator have plans to equip with RNP APCH capability in the future?
- What would motivate the operator to equip with RNP APCH capability in the future?
- What type of RNP APCH operation is preferred by the operator?
- Would the potential removal of a conventional procedure cause any particular problem? If yes, which one?
- At which airports would the operator like to have RNP APCH published and to which minima (LNAV, LNAV/VNAV and/or LPV)?

5.2.7.2.5. Information regarding the airworthiness and operational approvals of the aircraft operators registered in the State should be available from the Civil Aviation Authorities. Additional sources of information to the survey can be used to evaluate the fleet capabilities. EUROCONTROL is building a database (PRISME) including all aircraft types operating in ECAC and their navigation capabilities. In some cases given a particular type of aircraft, an estimate can be made regarding its navigation capability.

5.2.7.2.6. The data collected through the survey and other sources of information should be compiled to provide meaningful information to the project team for choosing among candidate RNP APCH procedures to be implemented.

5.2.8. Activity 7: ATC and NOTAM services

5.2.8.1. Assessment of the impact that RNP APCH implementation may have on the ATC and AIS services needs to be performed.

5.2.8.2. PANS ATM, ICAO Doc 4444 [8] covers the case of RNP APCH and provides applicable phraseology for ATC to manage RNP APCH. With existing standards, ATC will not be aware of the type of minima the crew will fly to.

5.2.8.3. In most cases, RNP APCH is performed on pilot demand and the name of the approach chart (RNAV Runway xx) is to be used in the approach clearance.

5.2.8.4. In other specific cases such as an RNP APCH with only an LPV line of minima and without an LNAV minima line, specific phraseology may need to be developed. This is not addressed in existing standards.

5.2.8.5. Amendment 1 to the 5th Edition of Doc 4444 introduces the new ICAO flight plan provisions effective from 15 November 2012. In line with Amendment 1, aircraft navigation equipment and capability for PBN applications, including RNP APCH, are catered for through the application of dedicated indicators in items 10 and 18 of the flight plan. *Entries made under Items 10 and 18 of the FPL will indicate the equipment level and capabilities of the aircraft.* ATS automated systems need to be upgraded to be able to extract this information from the FPL and it would need to be agreed what information to display on ATC working positions. However, ATC do not require detailed information about the PBN equipment on board an aircraft requesting to carry out an RNAV approach. The pilot requesting an RNAV approach is expected to be capable of conducting the type of approach requested. RNP APCH implementation can consequently be planned independently of the new FPL provision introduction. An exhaustive presentation of Flight Plan modifications is available on the site of EUROCONTROL Central Flow Management Unit at <http://www.cfm.eurocontrol.int>.

5.2.8.6. In order to support pre-flight planning, models of GPS and EGNOS allow predicting the impact on the navigation service of known and scheduled GNSS systems/subsystems outages. EUROCONTROL makes available a web-based service called Augur (<http://augur.ecacnav.com>) which provides GPS RAIM predictions to users. It (will) also display information about EGNOS availability to support LPV operations, according to information provided by the ESSP.

5.2.8.7. Such GPS RAIM and LPV availability predictions may also be provided in the form of NOTAMs . The ESSP can provide relevant information for

EGNOS NOTAMs to interested NOTAM Offices (for APV SBAS). The details of such a service are described and agreed with individual ANSP in the scope the EGNOS Working Agreement (EWA, as mentioned in section 5.2.6.4.6). Inputs for NOF to generate RAIM NOTAM are also available from other sources (e.g. the DFS). GPS RAIM NOTAM can also be generated by the EUROCONTROL Augur system.

5.2.9. Activity 8: Benefits and costs for RNP APCH implementation

5.2.9.1. Benefits

5.2.9.1.1. The main benefit of implementing RNP APCH is to improve safety. The RNP APCH operations reduce the risk of CFIT by providing stabilised approach. Also, better situational awareness is provided to pilots through provision of vertical guidance. RNP APCH implementation can support the withdrawal of some conventional nav aids thus saving costs for maintenance and flight calibration flights. This can lead to fewer building constraints on and around aerodromes and the possibility to develop and improve services.

5.2.9.1.2. The safety objective alone can be a sufficient argument to implement RNP APCH procedures, particularly in the cases when most aircraft operators in a particular airspace already have onboard RNAV capabilities. Some States have already implemented RNP APCH procedures for this purpose and their experience can be used by other States.

5.2.9.1.3. Nevertheless, if an ANSP or airport intends to perform a benefit assessment for implementing RNP APCH, the operational improvements that can be quantified are those associated with avoidance of delay and diversion that may result from the reduced operational minima possible with RNP APCH operations (particularly those when vertical guidance is provided – APV).

5.2.9.1.4. One way of performing such a benefit assessment is to use the Benefit Model [10]. This model describes a method of calculating the number of avoided cancellations and diversions based on meteorological data (cloud ceiling and runway visibility) versus the minima improvement. Such activity uses the information collected earlier in Activity 5. Please refer to [10] for more information.

5.2.9.2. Costs

5.2.9.2.1. The costs to implement RNP APCH should be estimated for all stakeholders such as ANSPs, Airports and Aircraft Operators.

5.2.9.2.2. Costs for ANSPs and/or Airports may emerge from the following:

- Procedure design and implementation costs which may include flight trials for validation, chart preparation and AIP changes
- Safety assessment
- Runway upgrades as identified in Activity 5 – e.g. upgrade of runway lighting
- Operational approval costs may include but are not limited to implementation of changes to airspace, design and publication of terminal procedures etc.
- ATC training in Performance Based Navigation – the same cost as for training in conventional navigation

5.2.9.2.3. The implementation of RNP APCH procedures that are based on the use of GNSS do not require the installation of ground navaid infrastructure. Consequently, there is a potential for cost saving for ANSPs if a rationalisation of conventional navaids infrastructure happens together with the deployment of RNP APCH.

5.2.9.2.4. The costs for aircraft operators will depend on the type of aircraft used (see information collected in Activity 6). This cost may include:

- Equipment acquisition and installation
- Airworthiness and operational approval
- Crew training

5.2.9.2.5. Experience has shown that operators must see clear benefits before deciding to acquire and install avionics. It is most important that service providers and aircraft operators coordinate their investments.

5.2.10. Activity 9: Choose which type of RNP APCH to implement

5.2.10.1. At this stage of the process, outputs from earlier activities are available to the team in order to arbitrate between different scenarios for implementing RNP APCH operations.

5.2.10.2. The rationale behind all the decisions taken should be documented in an implementation plan

5.2.10.3. The implementation plan should include at least the following elements:

- The rationale behind the particular RNP APCH implementation, the target strategic objectives and the expected benefits.
- The target airspace users (air transport, business, general aviation etc.).
- A deployment strategy which clearly indicates which RNP APCH (with minima LNAV, LNAV/VNAV and/or LPV) will be implemented and for which runway end.
- Note that all three levels of RNP APCH can be published on a single chart only in the case where the procedure design solution for LNAV does not utilize step-down fixes within the final approach segment. In this case, it is recommended that RNP APCH (LNAV) and RNP APCH (LNAV/VNAV and/or LPV) should be published on separate charts. The application of the ICAO duplicate procedure identification concept i.e. usage of a single letter suffix may also be considered.
- It is recommended that, whenever possible, all three levels of RNP APCH procedure be implemented at the same time for a particular runway.

5.3. B-III Process 2: RNP APCH implementation

5.3.1. General

5.3.1.1. Process 2 consists of all activities required to deploy the RNP APCH implementation plan resulting from Process 1.

5.3.2. Activity 10: Procedure design

5.3.2.1. The procedure design criteria for RNP APCH operations are relatively new, therefore limited expertise is available today. Early identification of any issue related to procedure design expertise would allow time for training and procurement of such know-how that is indispensable during next implementation phase. Special consideration should be given when designing an LNAV RNP APCH procedure using step-down fixes. The use of the step-down fix is a valid design criteria permitting additional descent within a segment by identifying a point at which a controlling obstacle has been safely over-flown. However, due to the fact that RNP APCH procedures rely on navigation databases and Flight Management Systems (FMS) it has been recognized that there are some avionics limitation in handling coded step-down fixes (SDF) within the final approach segment. It is also clear that some State regulators will not accept SDFs in the final segment coded into the navigation database under any circumstances. In that case, the State regulator that does not accept SDF coding, should advise the navigation data-houses through an official letter. It is highly recommended to publish for each SDF both the procedure altitude to be maintained to the SDF (along the profile) and the minimum obstacle clearance altitude (MOCA) available up to the SDF (as a shaded block). These two values are very often different and publishing both is of helpful for pilots.

5.3.2.2. ICAO Doc 8168 (PANS OPS) Volume II, Part III, and ICAO Annex 10 Volume I include requirements for RNAV training for procedure designers. However, it is recognised that the current ICAO material does not provide for the complete training needs of procedures designers. ICAO Doc 9906 Volume 2 — Flight Procedure Designer Training provides additional guidance for the establishment of flight procedure designer training. Training is the starting point for any quality assurance programme. This volume provides guidance for the establishment of a training programme.

5.3.2.3. Procedure design will be performed accounting for the categories of aircraft operating on the airport (see outcomes of Activity 6)

5.3.2.4. The procedures design criteria regarding different RNP APCH operations can be found in ICAO Doc 8168 – Aircraft Operations (PANS OPS) [11].

5.3.2.5. The criteria for RNP APCH procedures to LNAV minima (non-precision approach) are provided in ICAO PANS OPS Volume II, Part III, Section 3, Chapter-3.

5.3.2.6. The criteria for RNP APCH with vertical guidance based on Baro VNAV (APV Baro-VNAV) design are described in ICAO PANS OPS Volume II, Part III, Section 3, Chapter 4.

5.3.2.7. The criteria for RNP APCH with vertical guidance based on SBAS (APV SBAS) criteria are provided in ICAO PANS OPS Volume II, Part III, Section 3, Chapter 5.

5.3.3. Activity 11: Validation of expected benefits

5.3.3.1. At this stage of the process, the actual minima enabled by RNP APCH procedure are known (Activity 10). It is consequently recommended to verify that the benefits that were identified in Activity 8 are still valid.

5.3.4. Activity 12: Local Safety Case

5.3.4.1. The Local safety case shall start as soon as possible because the analysis can have an impact on the design or on the charting of the procedure.

5.3.4.2. EC Regulations 2096/2005 and 1315/2007 require that risk assessment and mitigation activities are carried out before implementing any change in the ATM/ANS. Indeed implementing RNP APCH is a change which requires such activities under oversight by the competent authority.

5.3.4.3. Finally, and in anticipation to implementation, a performance and safety monitoring system and procedures should be defined. This will include an occurrence reporting mechanism.

5.3.5. Gate: Final decision to implement

5.3.5.1. Once Activities 10, 11 and 12 are completed, the implementation plan developed earlier can be updated according to the latest conclusions.

5.3.5.2. Additionally, the following tasks can be performed:

- A notice on any potential airspace design change that can result from RNP APCH implementation.
- Notification of intent to operators by ANSP to implement RNP APCH.
- Notification of intent to operators for any removal of conventional procedures, if any conventional procedures are to be removed.
- A planned date for implementation should be announced.

5.3.6. Activity 13: Procedure validation

5.3.6.1. Once designed, the procedure should undergo a validation process. The objective of procedure validation is to verify obstacles and navigation data and assess the fly ability of the procedure.

5.3.6.2. Validation will consist of ground validation and maybe also flight validation. Ground validation must always be undertaken. When ground validation can validate the accuracy and completeness of all obstacles and data considered in the procedure design and any other factors normally considered in the flight validation, then the flight validation requirement may be dispensed with.

5.3.6.3. The process of quality assurance regarding the elements of procedure design, such as procedure design documentation, verification and validation methods, and guidelines on acquisition and processing of source data are described in ICAO Doc 9906 – Quality Assurance Manual for Flight Procedure Design, Volume 1 [13].

5.3.7. Activity 14: ATC Handling of Mixed-Mode Operations

5.3.7.1. Depending on the fleet mix, it is very likely that a certain number of aircraft operating at the airports where RNP APCH operations are to be introduced would not be capable of performing them or capable but not approved. Therefore, ATC must be capable of retaining a sufficiently high level of safety and performance of its service provision even in a mixed-mode environment *where there is a mix of aircraft using conventional and area navigation*.

5.3.7.2. RNP APCH procedures providing vertical guidance may be published either as backup for precision approaches or as sole approaches when there is no ILS/MLS. When they are published as a back-up to an ILS procedure it is helpful to design the RNP APCH procedures as an overlay of the existing precision approach in order to assist ATC in managing the transition in case the ILS becomes unavailable.

5.3.7.3. When an RNP APCH procedure is published, it is possible that not all the three minima lines are available on the chart. Aircraft approved for APV Baro-VNAV down to LNAV/VNAV minima cannot fly the published APV SBAS down to LPV but SBAS equipped aircraft approved to fly to LPV minima can fly the APV Baro-VNAV procedure to LNAV/VNAV minima. Where possible, all procedures should include an LNAV minima *in accordance with ICAO resolution A37-11* and aircraft approved for either APV Baro-VNAV or APV SBAS may use the LNAV minima line. It is recommended that where possible all three minima lines are provided.

5.3.7.4. If required, certain provisions should be implemented to enable the ATC to cope with mixed mode operations (conventional navigation vs area navigation where some aircraft are equipped to fly the RNP APCH and others are not). It may be necessary to provide a service to aircraft that are not capable and/or approved of RNP operations at all. Conventional procedures would therefore need to be retained. Conventional navigation aids may also be needed to support operators' contingency procedures in case of a GNSS outage.

5.3.8. Activity 15: AIS Requirements

5.3.8.1. Approach publication

5.3.8.1.1. For charting, general criteria apply as specified in ICAO PANS OPS Volume II, Part I, Section 4, Chapter 9. The title of the instrument approach chart shall be RNAV(GNSS) Rwy XX. The minima box could include OCA/H values for NPA (LNAV), APV Baro-VNAV (LNAV/VNAV) and LPV minima. An example of a chart that includes all three minima lines is provided in Figure 4.

5.3.8.1.2. When possible, it is recommended to have one RNAV chart including all three minima lines, i.e. LNAV, LNAV/VNAV and LPV. If multiple RNAV approaches exist to the same runway, a suffix is added to each of the applicable approach identifiers, for example RNAV (GNSS) Y RWY 27 and RNAV (GNSS) Z RWY 27. The Z suffix normally represents the preferred approach. Using a suffix is a common rule not specific to RNP APCH procedures.

5.3.8.1.3. Procedure designers need to ensure that the procedures can be coded in ARINC 424 format. They have to be familiar with the path terminators used to code RNAV systems and functional capabilities of different RNAV systems. A close co-operation should exist between procedure designers and the data houses that compile the coded data for the navigation database. Both procedure designers and data houses belong to the ANSP family according to the EASA Basic Regulation. All procedures must be based upon WGS-84 coordinates.

5.3.8.1.4. The State AIP should clearly indicate that the navigation application is RNP APCH. The navigation data published in the State AIP for the procedures and supporting navigation aids must meet the charting requirements of Annex 4 ‘Aeronautical Charts’, Chapter 11, paragraph 11.10.9 and Annex 15 ‘AIS’ (as appropriate).

5.3.8.1.5. A coding table or a formal textual description should be published on the back of the chart providing the coordinates of all the waypoints (and Fixes) used in the procedure. If it is not possible to put this information on the back of the chart a separate, properly referenced sheet can be used.

5.3.8.1.6. In the case of LPV, the data required to code the procedure includes a FAS Data Block, which contains an eight character hexadecimal representation of the calculated remainder bits called the CRC remainder. The CRC remainder is used to determine the integrity of the FAS data during transmission and storage and it is computed electronically using a FAS data block software tool. The content of the FAS Data Block should be published on the verso of the chart in order to ensure that the procedure is correctly coded in the navigation database.

5.3.8.1.7. A FAS DB tool is made available by EUROCONTROL (<http://fas.ecacnav.com>). This tool allows the calculation of the CRC value for a FAS DB, generates an electronic version of the FAS DB and converts electronic FAS DB into a textual form. Generally, FAS DB tools also generate a Data Block representation as a hexadecimal string. It is recommended that the textual description only, together with the CRC remainder value should be made available on the verso of the chart.

5.3.8.1.8. Experience gained by certain States through recent implementation projects highlights the importance of good project management allowing a reasonable amount of time for unexpected events, especially those related to procedure coding. For example, four months

were actually needed for a procedure to become available in the navigation database, instead of the planned two months and a half.

5.3.8.1.9. Another detail concerning the publication of LPV procedures is that a unique SBAS channel number is needed for every published approach. ICAO will implement a global system of SBAS Channel assignments. Currently, as agreed with ICAO and FAA, EUROCONTROL is the focal point in Europe for SBAS channel allocation. The Procedure designer is expected to request the appropriate organisation for a channel number. . The SBAS channel number is a five digit number that must be regionally unique and shall be in the range of 40,000 to 99,999. Channel number assignments are required for LPV and LP procedures and shall be promulgated on the SBAS LPV and LP approach charts respectively. It should be noted that SBAS LP minima will not be published at the same location as SBAS LPV minima. LP procedures will only be published at locations where LPV is not possible.

5.3.8.1.10. The information regarding the establishment of new RNP APCH procedure(s) shall be provided in accordance with the AIRAC system. It is recommended that new RNP APCH procedures should be considered by States AIS as ‘major changes’ in respect of circumstances listed in Appendix 4, Part 3 of ICAO Annex 15 (guidance on what constitutes a ‘major change’ is included in Doc. 8126 ‘AIS Manual’). Therefore, it is recommended that new RNP APCH information should be distributed by the AIS unit at least 56 days in advance of the planned effective date.

5.3.8.2. AIC and AIP publication

5.3.8.2.1. States are recommended to use AIC and AIP to provide information to users regarding the GNSS and SBAS. Both type of avionics i.e. basic GNSS and augmented GNSS (SBAS) support all phases of flight from departure through RNP approach. GNSS-related elements providing the navigation service for en-route purposes shall be published in the State AIP ENR 4 section. When the same aid i.e. Basic GNSS and/or SBAS is used for both en-route and aerodrome purposes, a description must also be given in AIP AD 2 and/or (if appropriate) AD 3 sections.

AIP
FRANCE

AD2 LFRB IAC 09
03 MAY 12

APPROCHE AUX INSTRUMENTS

BREST BRETAGNE

Instrument approach

CAT A B C D

ALT AD : 325, **THR : 289 (10 hPa)**

RNAV (GNSS) RWY 07R

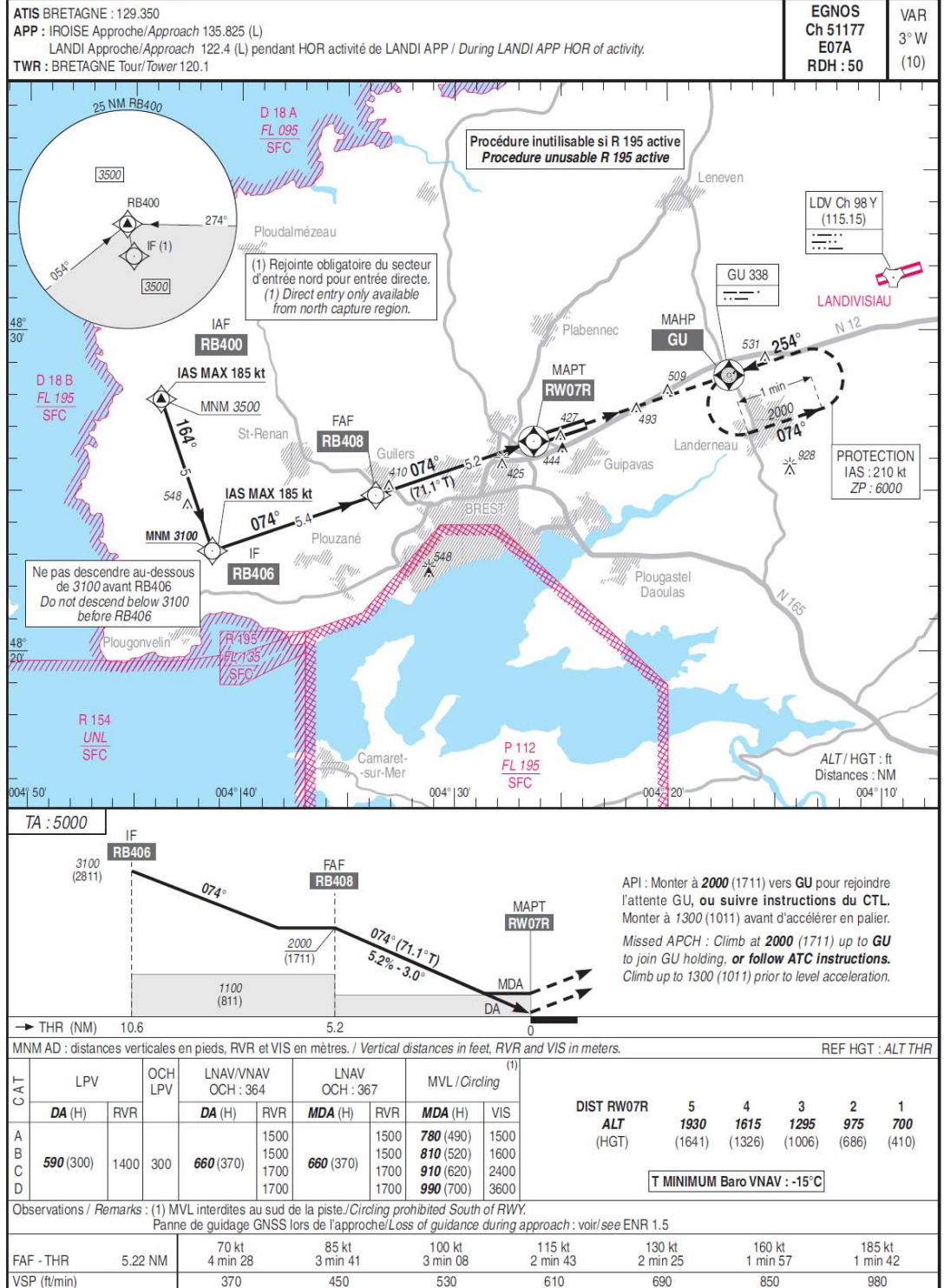


Figure 4 Example RNAV Approach Chart including all three minima lines

5.3.9. Activity 16: Navigation Database

5.3.9.1. The navigation database should be obtained from a supplier that complies with RTCA 200A/EUROCAE ED-76A ‘Standards for Processing Aeronautical Data. A Letter of Acceptance (LoA) type 1 granted by the appropriate regulatory authority shall demonstrate data house compliancy with the above mentioned standard requirement.

5.3.9.2. Virtually all aeronautical databases are loaded according to the specifications in the Aeronautical Radio, Incorporated (ARINC) 424 standard ‘Navigation System Data Base’. While the ARINC 424 specification covers a large percentage of the aeronautical requirements, it is impossible to write a specification that wraps up every combination of factors used to design and fly instrument procedures.

5.3.9.3. Many of the differences between charts and databases are because there can be no standard implemented to have the information in both places depicted in exactly the same way. It is recognized that the basic design for most aeronautical information contained in instrument procedures i.e. conventional ones has been created for the analogue world. The art of entering data into an aeronautical database i.e. translation of the textual & graphical description of a procedure with the help of Path and Terminator (P/T) codes is one that balances the intent of the original procedure designer and the requirements of FMC systems. With the implementation of RNAV and RNP type of applications, a high degree of standardization and harmonization chart – database information has been reached due to following reasons:

- RNAV approach procedure standard shape ‘Y’ or ‘T’;
- Mostly straight segments (TF leg);
- Small sub-set of P/Ts compatible for RNAV procedure coding;
- ICAO requirement for formal or tabular procedure description on chart verso which significantly diminished the miss-interpretation of procedures by coders;

5.3.9.4. However, there are many different types of avionics equipment utilizing the same baseline database. The same database information may be presented differently on certain types of airborne equipment even being manufactured by the same FMS vendor. In addition, some equipment may be limited to specific types of database information, omitting other database information.

5.3.9.5. For nearly two decades data-house experts have been working with all avionics vendors to achieve as much standardization of RNAV procedures as possible. In certain cases, alternative coding (such as path terminators, speed and altitude restrictions) may be used to enable specific RNAV systems to better follow the intended track.

5.3.9.6. Within an ARINC 424 output file for an SBAS LPV procedure, the FAS DB data is carried in a dedicated type of record called the Path Point (PP) file. The PP Primary record description contains all FAS data fields (twenty-one fields including the CRC remainder field) as required for the data wrap for CRC calculations. The specific order and coding of the twenty-one fields shall be followed rigorously when computing the CRC to ensure avionics compatibility. When ‘un-wrapping’ the FAS Data Block, the

data-house and avionics must compare the resulting CRC remainder i.e. representing integrity field with the value provided by the procedure designer. If the values do not match, the FAS Data Block cannot be validated and extracted from database.

5.3.9.7. Additionally, the Path Point record has been further extended following industry requirements with a continuation record. The PP Continuation record containing fields such as LTP and FPAP orthometric heights, FPAP ellipsoid height and SBAS channel number. Therefore, States are also required to provide *these parameters to the data houses in addition to the FAS DB*.

5.3.9.8. In conclusion, RNP APCH procedures authorized for SBAS navigation demand a complex work-process for generation and extraction of the complete set of records by the navigation database supplier.

5.3.9.9. From a data quality and integrity level stand point, some elements of the FAS DB are classified as critical data requiring the highest possible resolution for latitude/longitude & elevation (hundredth of sec and 1 foot respectively). Therefore, attention should be paid throughout the entire chain of involved actors i.e. procedure designer – AIS expert - data ware-house specialist – avionics representative in order that the high demanding navigation database requirements for RNP APCH should be closely coordinated as well as it would be a collaborative process.

5.3.10. Activity 17: Training Requirements

5.3.10.1. Training for ATC

5.3.10.1.1. Air traffic controllers, who provide control services at airports where RNP approaches have been implemented, should have completed training that covers the items listed below.

5.3.10.1.2. Core training

a)How area navigation systems work:

- include functional capabilities and limitations;
- accuracy, integrity, availability and continuity including on-board performance monitoring and alerting;
- GPS receiver, RAIM, FDE, and integrity alerts;
- waypoint fly-by versus flyover concept (and different turn performances);

b)Flight plan requirements;

c)ATC procedures;

- ATC contingency procedures;
- separation minima;
- mixed equipage environment;
- transition between different operating environments; and
- phraseology.

5.3.10.1.3. Training specific to RNP APCH

- a) Related control procedures:
 - radar vectoring techniques (where appropriate);
- b) RNP approach and related procedures:
 - including T and Y approaches; and
 - approach minima;
- c) impact of requesting a change to routing during a procedure.

Some items of the training are general. Local considerations may be added as result of the local safety assessment.

5.3.10.2. Training for Flight Crew

5.3.10.2.1. A training syllabus for flight crew is provided in the AMC 20-27 and AMC 20-28 [21, 22].

5.3.11. **Activity 18: Final Review before implementation**

5.3.11.1. Once the above steps are performed, a final verification should be performed so that the deployment is actually made.

5.3.11.2. The following list is proposed as a check list for this final review:

- Demonstrate how the targets set for the implementation of the RNP APCH procedures are to be met.
- The risk assessment and mitigation for the change must be accepted by the competent authority.
- The validation of the procedures must have demonstrated that the procedures can be successfully implemented
- The impact on training and the level of fleet equipage on implementation date must be considered and if needed, a new target date for implementation should be agreed.
- In case a GO decision has been made, a commitment to implement and the agreed target date for the publication of the procedures should be announced.

5.3.12. Activity 19: Introduction into service

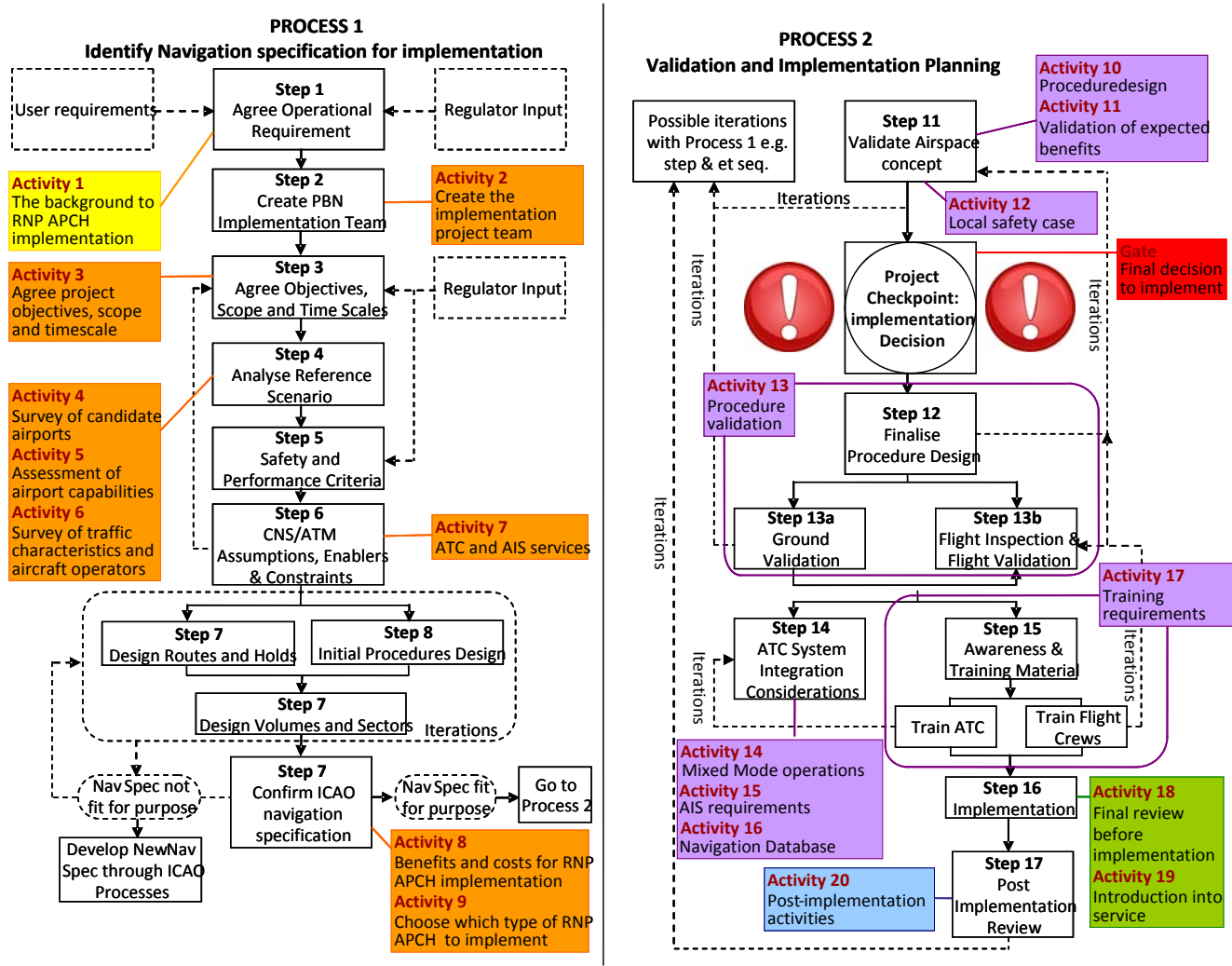
5.3.12.1. At this stage, predefined safety and performance monitoring tools and procedures need to be put in place, including an occurrence reporting mechanism.

5.3.13. Activity 20: Post-implementation activities

5.3.13.1. Once the RNP APCH operations are introduced, their performance should be monitored. For this purpose, data on success and failure rate of RNP APCH should be collected.

5.3.13.2. If unacceptable events occur during initial operations, the procedures should be removed and the operational concept should be reviewed in order to put in place the appropriate mitigations.

Annex 1: Activity mapping to ICAO implementation steps



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