Chapter 9 RNP APCH

1. General

RNP APCH is the general ICAO designator for PBN approach procedures that are not Authorization Required operations.

Both RNAV (GNSS) and SBAS LPV procedures are types of RNP APCH operations, as GNSS fulfils the basic requirement of RNP for on-board performance and monitoring.

RNP APCH procedures will be identified as:

- RNP APCH – LNAV
- RNP APCH – LNAV/VNAV (where a vertical guidance system is used)
- RNP APCH – LPV (Localiser Performance with Vertical Guidance)
- RNP APCH – LP (SBAS approach where vertical guidance is not available)

As the PBN Manual has yet to be amended to include navigation specification for LPV approaches this Chapter currently only deal with RNP APCH – LNAV procedures.

2. Characteristics

The main characteristics of RNP APCH LNAV operations are:

- IAL chart tiled RNAV (GNSS)
- Approach path constructed as series of straight segments
- Descent to an MDA which is published as an LNAV minima
- Can be flown using basic GNSS (TSOC129a) equipment or RNP 0.3 capable aircraft
- Obstacle clearance lateral tolerances not based on RNP value
- Vertical flight guidance (e.g. Baro-VNAV) may be added

3. Flight procedure design

Although RNAV (GNSS) approach procedures are designated in the PBN concept as RNP APCH – LNAV procedures there has been no change to the method of procedure design which is in accordance with PANS-OPS $\text{RNAV}_{\text{(GNSS)}}$ design criteria.

Instrument approach charts continue to include RNAV $_{\text{(GNSS)}}$ in the title, and descent is made to a minimum descent altitude which is shown as an LNAV minimum or LNAV/VNAV where vertical guidance is available.

RNAV $_{\text{(GNSS)}}$ procedure design criteria are not currently based on an RNP requirement but on the performance capability of a basic TSO C129a GPS receiver. However it is considered that an aircraft with RNP 0.3 capability has at least equivalent performance and a number of States have authorised RNAV $_{\text{(GNSS)}}$ operations based on RNP 0.3 capability.

The RNAV $_{\text{(GNSS) Approach}}$ plate shown in Fig 9.4 is an example of an RNP APCH LNAV/VNAV procedure. Although there is no specific notation, this type of approach can be flown by aircraft equipped with either a stand-alone GNSS receiver or an FMS equipped aircraft with RNP 0.3 capability.

When flown as an LNAV operation, the altitude limitation at C02LS (660') applies, and decent is to an MDA of 580'. The missed approach point for this procedure is located at the runway threshold (RW 02L) and pilot action is required at this point to initiate flight plan sequencing for navigation past the MAPt for stand-alone GNSS receivers.

Note: In this example there is no missed approach turning or holding fix and a pilot-interpreted heading is flown, and therefore no track guidance is provided after the MAPt.
The 3º VPA and the on-slope altitude at C02LS in this case are advisory only (although recommended) and the flight crew responsibility is to ensure descent not lower than 660ft until passing C02LS.

If flown as an LNAV/VNAV approach, the fix and altitude limitation at C02LS is not relevant, and from the FAF at C02LF the approach is flown as a VNAV approach to the DA (530'). The MAPt in this case is not relevant.

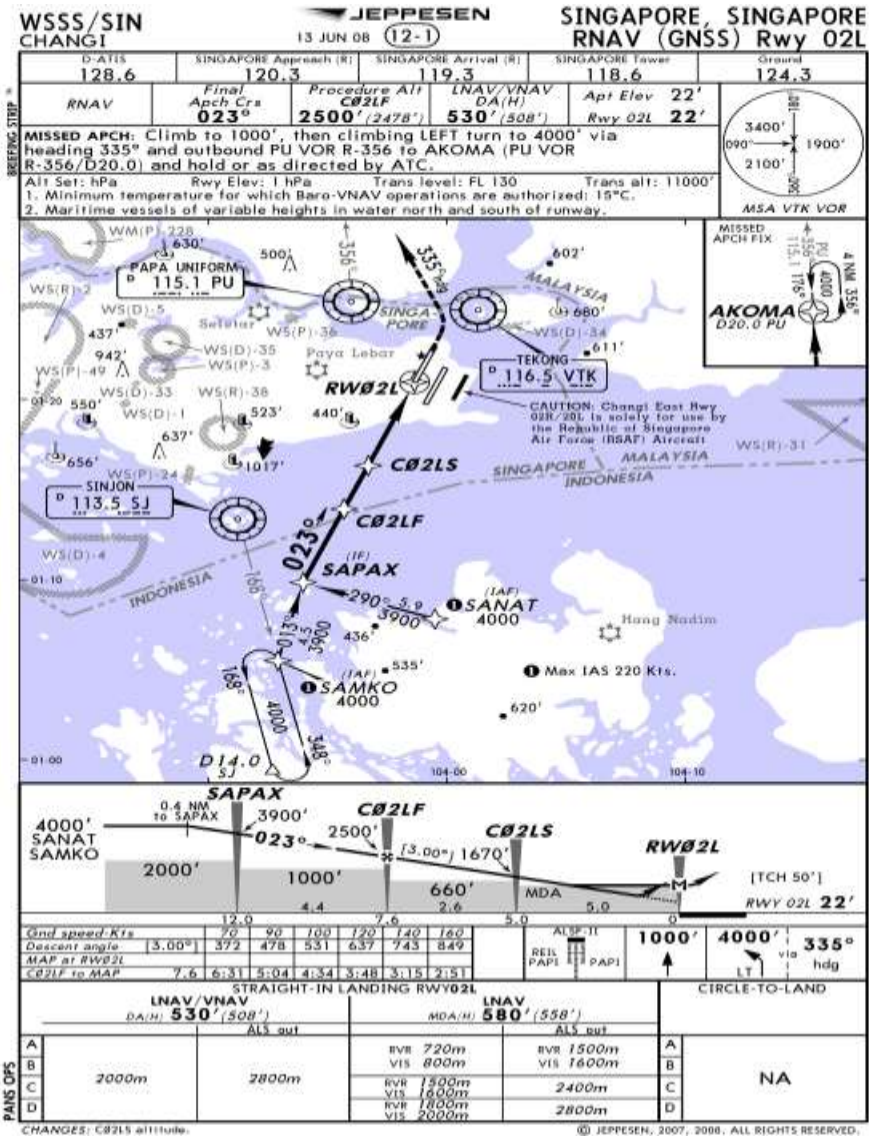

Figure 9.4 RNAV (GNSS) Approach Chart with LNAV and LNAV/VNAV Minima

Caution: Different coding is required for approaches flown using stand-alone GNSS equipment and FMS equipped aircraft, as stand-alone receivers require specific identification of certain waypoints (FAF, and MAPt) in order to initiate automatic CDI scaling, alerting levels and waypoint sequencing. FMS equipped aircraft to not require such coding. Incorrect coding can lead to some FMS equipped aircraft interpreting a MAPt located prior to the threshold as the origin of the VPA and undershooting can occur.

4. Operational approval

Operators currently approved to conduct RNAV $_{(GNSS)}$ approaches qualify for RNP APCH – LNAV without further examination.

5. Navigation systems

In general the navigation systems available for RNP APCH – LNAV operations fall into two distinct categories:

- Stand-alone GNSS receivers

- RNP capable FMS equipped aircraft

Although both types of navigation systems have similar capability there are significant differences in functionality, cockpit displays, and flight crew procedures.

6. Stand-alone systems

This type of system is commonly represented by a panel-mounted self-contained unit comprising a GNSS receiver incorporating a control unit, a lateral deviation indicator, and an annunciator panel. In some cases the unit may also include a map display. Units may also be installed with a separate CDU, or a separate map display.

Commonly installed in general aviation aircraft, this type of system is also frequently installed in commuter airline aircraft and occasionally in older jet air transport category aircraft.

For IFR approach operations, the installation must provide a lateral deviation displayed on a CDI or HSI in the pilot's primary field of view. This is normally done by connecting the GNSS receiver output to a dedicated CDI or by enabling the selection of the navigation source to the primary HSI/CDI to be selected. (The in-built CDI provided on most stand-alone GNSS receivers is generally not considered adequate, even if the unit is installed in the pilot's primary field of view.)

An annunciator panel is standard equipment for approach operations and must be located in a suitable position on the instrument panel. Navigation mode annunciation of terminal mode, approach armed, and approach active is required.

Figure 9.5: Typical Stand-alone GNSS installation

In this type of installation, mode switching from en-route, terminal, to approach is automatic, provided certain conditions exist. Provided a suitable flight plan is loaded which enables the

receiver to identify the destination airport, the unit will automatically switch to terminal mode at 30NM from destination ARP. CDI scaling automatically reduces from +/- 5NM en-route mode scaling to +/-1NM terminal mode scaling and the RAIM alert limit reduces to 1NM.
At 2NM from the FAF, the receiver checks that approach RAIM will be available and provided the aircraft is on or close to track, the receiver will ARM and the CDI scaling will gradually reduce to +/- 0.3NM. Any off track deviation as the FAF is approached will be exaggerated as CDI scaling changes, and the flight crew can be mislead if the aircraft is not flown accurately or if the effect of scale change is not understood.

An APPROACH annunciation must be observed before crossing the FAF and continuing with the approach. If APPROACH is not annunciated the approach must be discontinued.
During the approach distance to run is given to the Next WPT in the flight plan, and not to the runway. Minimum altitudes are commonly specified, at a WPT or as a distance TO a waypoint. Situational awareness can be difficult and it is not uncommon for pilots to confuse the current segment and descend prematurely.

Cross-track deviation should be limited to ½ scale deflection i.e. 0.5NM on initial/intermediate/missed approach segments and 0.15NM on final. A missed approach should be conducted if these limits are exceeded.

Note: Operating practice differs between States on the cross-track error at which a go-round must be initiated. Although the design of RNP APCH – LNAV procedures is not based on the RNP level, they may be flown by aircraft capable of RNP 0.3. For aircraft operations based on RNP capability, normal operating practice requires a go-round at 1 x RNP. For stand-alone systems therefore a go-round must be conducted at full-scale deflection (0.3NM).
At the MAPt, which is commonly located at the runway threshold waypoint sequencing is inhibited, on the assumption that the aircraft is landing. If a missed approach is conducted pilot action is normally required to sequence to the missed approach. Depending on the procedure design (coding) defined track guidance in the missed approach may not be provided, and crews need to understand the navigation indications that are provided and the appropriate technique for managing the missed approach.

On sequencing to the missed approach the receiver automatically reverts to terminal mode.
Close attention needs to be placed on the human factors associated with approaches flown using this type of equipment.

7. Flight Management Systems

RNP APCH – LNAV operations conducted in aircraft equipped with an FMS and GNSS are managed very differently to stand-alone systems.

As discussed above, RNP APCH procedures are designed using RNAV $_{(GNSS)}$ criteria which were not developed on the basis of GNSS performance rather than an RNP requirement. However it can be shown that an aircraft capable of RNP 0.3 approach operations meets or exceeds the navigation tolerance requirements for RNAV $_{(GNSS)}$ approach procedure design. FMS equipped aircraft therefore are able to fly RNP APCH –LNAV procedures provided RNP 1.0 is selected for the initial, intermediate and missed approach segments, and RNP 0.3 for the final approach segment.
Positioning data, including GNSS, is commonly combined with IRS and radio position to compute an FMS position. The GNSS receiver, which may be separate or part of a multi-

mode receiver, provides position data input but does not drive automatic mode switching or CDI scaling. Navigation system integrity may be based on RAIM, but more commonly is provided by a hybrid IRS/GNSS system, which can provide significantly improved integrity protection and availability.

Most FMS aircraft are not equipped with a CDI type non-numerical lateral deviation indicator, although some manufacturers offer a lateral deviation indicator as an option. Where a lateral deviation indicator is provided, the scaling is determined by the manufacturer and may be either a fixed scale or a non-scaled system. Lateral deviation scales may only be available (either automatic or selectable) for certain phases of flight. Automatic scaling similar to stand-alone systems is not provided.

Lateral deviation in this type of system is commonly displayed as a digital cross-track deviation on a map display. Digital cross-track deviation is normally displayed in 1/10th NM, although 1/100th is often available as an option. Digital cross-track deviation may also be subject to rounding. For example where the display threshold is set at 0.15NM on a display capable of only 1 decimal place, the first digital indication of cross-track deviation is displayed as 0.2NM. In the same example, as cross-track deviation is reduced, the lowest value displayed is 0.1NM rounded down when the actual deviation reaches 0.15NM.

Monitoring of deviations within the limits of the navigation specification (0.15NM on final approach) using digital cross-track indications alone can be difficult in some cases. In the example in the previous paragraph the first digital indication of cross-track error is displayed at 0.2NM (although this indication is initiated at 0.15). However, a relative or graphical indication of cross-track error can be derived from the relative position of the aircraft symbol to the flight plan track on the navigation display. For this method to be satisfactory, the size and resolution of the map display needs to be sufficient, and a suitable map scale must be selected.

A go-round should be conducted if the cross-track error reaches 1 x RNP (0.3NM).

Modern large screen (10inch) multi-function displays at 10NM range are generally satisfactory and small deviations can be estimated sufficiently accurately to provide good initial indication of track divergence. Older and smaller displays, including LCD type displays can be less effective and subject to variation (jumping) in displayed position.

Additional cross-track deviation information may also be available on the CDU/MCDU which although outside the normal field of view can be monitored by the PNF/PM. In such cases the evaluation of cockpit displays must also take into consideration the crew operation procedures, callouts etc.

As turns for RNP APCH LNAV approaches are TF/TF transitions and initiation is based turn anticipation logic, track guidance during turns is not provided, and cross-track deviation indications are not provided with respect to a defined turning path. The lack of a defined path is accommodated in the design of the approach procedure, however, it is necessary for the turn to be initiated and correctly executed so that there is no significant under- or over-shooting of the subsequent leg.

In the evaluation cross-track deviation monitoring, it needs to be recognised that track adherence using autopilot or flight director for normal operations is generally very good and little of no cross-track deviation is observed. The evaluation should therefore concentrate on determining that in the unlikely event of a deviation that the crew has sufficient indications to detect and manage any deviation. Deviations can also occur due to delayed or incorrect NAV selection, delay in autopilot connection, autopilot inadvertent disconnection, turbulence, excessive adverse wind, OEI operations and other rare normal or no-normal events.

Navigation system alerting varies between aircraft systems, and unlike stand-alone systems is determined by logic determined by the OEM. Although the operational approval will not normally need to consider the methodology used, the basics of the alerting system must be understood and the approval needs to determine that the operator's flight crew procedures and training is consistent with the particular aircraft system.

The appropriate RNP for the initial and intermediate segment is RNP 1.0, in the FAS RNP 0.3NM, and RNP 1 for the missed approach. The most common method used to manage RNP is to select RNP 0.3 prior to the IAF, and retain that selection throughout the approach and missed approach. In some cases a default RNP for approaches may apply, and it is sufficient that the crew confirms the correct RNP is available. In other cases crew selection of RNP 0.3 prior to commencement of the approach is necessary. Changing the RNP after passing the IAF is not recommended as it increases crew workload, introduces the opportunity for error (forgetting to change the RNP), and provides little or no operational advantage. For RNP 0.3 operations availability is normally close to 100% and although RNP 0.3 may not be required for the majority of the approach (initial/intermediate segments) the probability of an alert due to the selection of a lower than necessary RNP is extremely low, especially as prediction for RNP 0.3 availability is required to conduct an approach.

Less commonly some systems allow the RNP to be automatically extracted from the navigation database.

8. Using VNAV advisory information

Barometric VNAV is commonly available on modern jet air transport category aircraft equipped with FMS. Other VNAV systems are also available (e.g. SBAS) although few aircraft in this category are fitted.

Aircraft in the general aviation, commuter and light airline categories are generally not equipped with an integrated lateral and vertical navigation system, (typically stand-alone GNSS systems) although increasingly business jets are fitted with capable VNAV systems.
RNP APCH LNAV approach procedures are not dependent upon VNAV and normal non-precision approach principles apply in which obstacle clearance is dependent upon minimum altitudes.

However most RNP APCH LNAV approach procedures are published to indicate an optimum approach gradient (normally 3°) above all minimum obstacle clearance altitudes. Despite there being no change to the underlying non-precision approach obstacle clearance requirements it is recommended that VNAV is used where available to manage the approach and assist in flying a stabilised constant angle flight path. Navigation database coding normally supports a flight path angle where identified on the instrument approach chart.

While the use of VNAV for this purpose is recommended, the operational approval needs to carefully examine the aircraft capability, VNAV functionality, mode selection and annunciation, mode reversion, operating procedures and crew knowledge and training.

It must be clearly understood that VNAV used in this way does not resolve the crew from the responsibility to ensure obstacle clearance is maintained by strict adherence to minimum attitudes by use of the pressure altimeter. Descent is made to the LNAV minima which is an MDA. An acceptable alternative method is to add a margin the LNAV minimum altitude (typically 50-100ft) and to treat the higher MDA as a DA, on the basis that any height loss during the go-round will result in descent not lower than the published MDA. In some States operational approval under certain circumstances may be available to consider the published MDA as a DA.

During the operational approval due attention should be placed to vertical navigation at all stages of the approach. Although an approach angle is normally only published for the FAS extension of the coded angle to the IF should be considered in order to provide additional protection and avoid potential problems with intercepting the vertical path. Operators will normally need to make a special request to the navigation database supplier for the extension of the vertical path angle coding.

Normally an approach will be designed so that the vertical path clears all minimum altitudes in the final approach segment by a convenient margin (50-100ft). This allows for some tolerance in the VNAV system and avoids any tendency to level off in order to observe any hard altitude limitations. Where a suitable tolerance is not provided consideration should be given to revising the design of the procedure to be more VNAV friendly.

9. VNAV approach guidance

Where an LNAV/VNAV minima is published the procedure has been designed as a vertically guided approach and obstacle clearance in the final approach segment is dependent upon the use of an approved VNAV system. Descent in this case is made to the LNAV/VNAV minimum which is a DA and minimum altitudes in the FAS do not apply.

RNP APCH LNAV/VNAV procedures are currently based upon the use of barometric VNAV, although satellite based vertical guidance may also be applicable.

The design of the vertical flight path is based upon a fixed minimum obstacle clearance (MOC) of 75m/246ft beneath the nominal vertical flight path. The MOC is assumed to contain all errors associated with the determination of the VNAV path, including vertical FTE. Separate allowance is made for the effect of any along-track error in the determination of the vertical path (horizontal coupling effect).

Note: RNP AR APCH procedures also incorporate vertical guidance using barometric VNAV but the method used to determine obstacle clearance is based on a statistical sum of the contributing errors, called the Vertical Error Budget (VEB) rather than a fixed MOC value.
As barometric VNAV is based on air density, the actual vertical flight path angle varies with temperature and low temperature results in a reduced flight path angle lowering the approach path and reducing obstacle clearance. In order to compensate for this effect an allowance is made for low temperature such that the designed vertical flight path angle clears all obstacles by the MOC (75m/246ft) plus an allowance for low temperature.

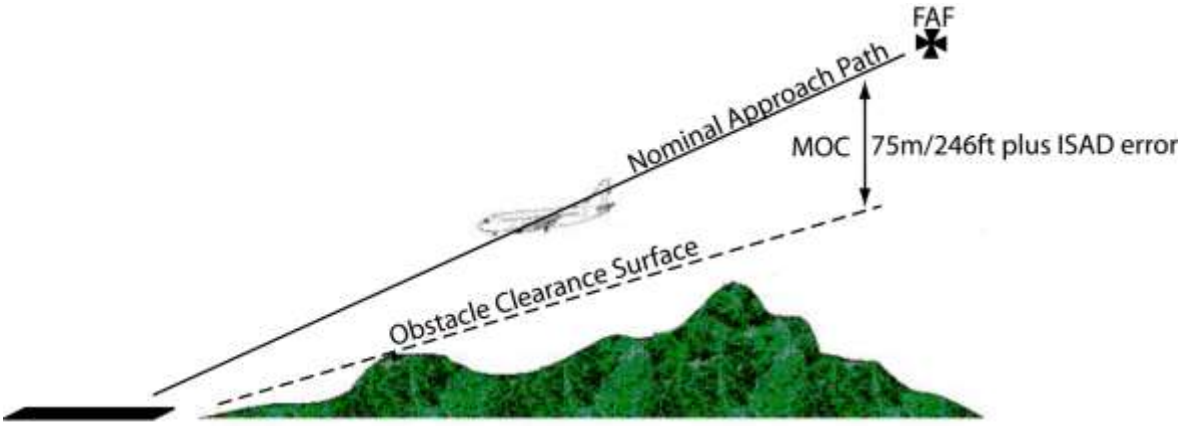

Figure 9.6: Baro-VNAV obstacle clearance for RNP APCH – LNAV

A low temperature limit may be published to ensure obstacle clearance is maintained at the lowest operating temperature. Temperature compensated VNAV systems are available which enable the design vertical flight path to be flown irrespective of temperature, although compensation is not commonly fitted to jet transport category aircraft.

Extension of the coded vertical path as far as the IF should also be considered in order to better manage interception of the VNAV path.

When conducting an LNAV/VNAV approach, the primary means of obstacle clearance is provided by the VNAV system rather than the altimeter, and adherence to the vertical flight path within reasonable tolerance is required.

ICAO Doc 8168 PANS-OPS Volume 1 provides operational guidance on the conduct of approach with barometric VNAV guidance. Vertical deviations from the defined path should be limited to +100/-50ft.

Note: To retain consistency with RNP AR APCH is expected that the PBN Manual will amend the vertical FTE limit to 75ft.

The operational approval needs to carefully examine the aircraft capability, VNAV functionality, mode selection and annunciation, mode reversion, operating procedures and crew knowledge and training.

10. Altimeter setting procedures

As the flight path guidance provided by a barometric VNAV system is directly affected by the barometric pressure subscale setting, particular attention needs to be placed to pressure setting procedures and associated aircraft systems.

11. Vertical Navigation Systems

Most commercial jet transport aircraft are equipped with a baro VNAV system that is compliant with FAA AC 20-129 which has been in existence for many years.

It can be difficult to reconcile the specified minimum barometric VNAV system performance requirements in the Attachment to the PBN Manual (which are derived from FAA AC 20-129) with actual VNAV operating practice. However the actual performance of installed VNAV systems has been demonstrated to provide accurate vertical guidance which meets the standard necessary for RNP APCH.

AC 20-129 makes the assumption that altimetry system error (ase) will be compensated and consequently no allowance is made for altimetry errors in the estimation of vertical TSE. In practice a residual error does exist in most aircraft and manufacturers are generally able to provide data. As a guide, **ase** is typically less than 60ft.

The FTE standard in the PBN Manual (and AC 20-129) is larger than is normally observed during approach operations. For example, the FTE requirement applicable to most approach operations is 200ft, compared to observed values which are commonly less than 60ft (3 σ). Potential errors associated with waypoint resolution, vertical path angle definition, and ATIS errors are not included.

Although a statistical analysis of VNAV component errors is not required for basic Baro-VNAV operations, it may be helpful to asses the typical VNAV errors, in a similar manner to that applied to Baro-VNAV for RNP AR APCH operations.

A root sum square calculation using typical PBN Manual VNAV equipment and FTE values, plus an allowance for other errors, provides the following result at a 5NM FAF.

$$\text{RSS TSE} = \sqrt{(VNAV)^2 + (FTE^2) + (ASE^2) + (WPR^2) + (VPA)^2 + (ATIS^2)}$$

$$= 234\text{ft}$$

Assuming:

VNAV equipment error (99.7%)	100ft
FTE (99.7%)	200ft
ASE (Assumed max 99.7% error)	60ft
WPR	3ft
VPA based on 1° resolution/0.5° error	26ft
ATIS (assumed 99.7%)	20ft

Note: Horizontal coupling error or ANPE is considered separately in PANS-OPS and does not need to be included.

This value is slightly higher than the figure given in the PBN Manual RSS value (224ft) but less than the 246ft MOC used in design.

Given that the commonly observed VNAV errors, including FTE (with autopilot) are significantly less than the values used in this example, the performance of a VNAV system compliant with FAA AC 20-129 can be expected to be consistent with the assumption of a 246ft fixed MOC.

Additional mitigation is also provided by the operational requirement to monitor the vertical FTE and conduct a go-round if the deviation below the vertical path exceeds 50ft (or 75ft if amended.)

For aircraft approved for RVSM operations the ASE and VNAV errors can be expected to be small. If any doubt exists as to the suitability of a particular VNAV system, additional data on actual in-service performance should be sought.

12. GNSS Availability Prediction.

As the current GPS constellation is unable to provide 100% availability at all levels of service, there are periods, depending upon a number of factors, when an RNP approach cannot be conducted. Consequently a prediction of availability is conducted to enable the flight crew and dispatchers (where applicable) to take into consideration the availability of GNSS capability to be expected at any particular location.

Availability of RNP APCH operations is normally limited by the approach HPL which is set to 0.3NM by default for stand-alone GNSS receivers. At this level of service, the periods when an RNP service is unavailable are short, and a delay in departure or en-route, is often sufficient to schedule an arrival when the service is predicted to be available.

An operation is not available, or should be discontinued when an alert is displayed to the flight crew. Consequently availability is determined by the means used to generate an alert, which as discussed previously, varies between aircraft. In order to be most accurate and effective a prediction of availability needs to be based on the same parameters that are used in the particular aircraft systems, rather than a general prediction of a parameter such as HPL.

The operator needs to make arrangements for prediction service to be available that replicates the monitoring system on the aircraft. Prediction services are readily available from a number of commercial sources. The prediction should be based on the latest satellite health data, which is readily available, and take into account other factors such as high terrain. On board prediction programs are generally unsatisfactory in that they are unable to take account of satellite NOTAMS and terrain masking.

NZQN
TSO-C129 (a) (and equivalent)
Fault Detection
No GPS RAIM FD Outages for NPA

TSO-C146a (and equivalent)
Fault Detection Only
No GPS RAIM FD Outages for NPA

TSO-C146a (and equivalent)
Fault Detection and Exclusion
0912230006 TIL 0912230019
0912231552 TIL 0912231557
0912240002 TIL 0912240015
GPS RAIM FDE Unavbl for NPA

Figure 9.7: Example of an availability forecast for RNP APCH

Note: The reference to NPA (Non-Precision Approach) in Figure 9.7 derives from the term GPS/NPA previously used to describe RNAV (GNSS) approaches.

While satellite prediction services are normally accurate and reliable it should be noted that an unpredicted loss of service can occur at any time. However safety is not compromised (provided adequate fuel reserves are carried) and on-board monitoring assures that the crew will be alerted and the approach can be discounted, delayed or an alternative approach conducted.

13. Radio updating.

The PBN Manual navigation specification permits the integration of other navigation sensor information with GNSS provided the TSE is not exceeded. Where the effect of radio updating cannot be established, inhibiting of radio updating is required.

The computed aircraft position is normally a mix of IRS/GPS and in some cases also DME and VOR combined using a Kalman filter. The manufacturer's stated RNP capability should take into account the method used to compute position and any weighting of navigation sources.

In the typical case IRS position is updated continually by GNSS and radio aid updating is either inhibited or weighted so as to have little effect or none on the computed position. When a source of updating is lost the position will be determined in accordance with a reversionary mode. If GNSS updating is lost, IRS position is normally updated by DME if available and VOR if insufficient DME stations are in view. As DME and particular VOR updating is much less accurate than GNSS there is some potential for degradation in the position accuracy.

If it can be determined that radio updating has no detrimental effect on the accuracy of the computed position, then no action is required.

However, it can be difficult to obtain conformation of the effect of radio updating, and where this cannot be determined, radio updating should be selected OFF. Most systems provide for a means for deselection of radio updating, either manually or by a pin selection option. Manual deselection can be an inconvenient additional crew procedure, although on at least one aircraft type a single button push deselection is available. Where possible a default option where radio updating is normally OFF is preferred, with the option of crew selection to ON in the unlikely event of a loss of GNSS updating.

14. Operating Procedures

In recent years most manufacturers have developed recommendations for RNAV (GPS)/RNAV (GNSS) procedures. Although the manufacturer recommendations should be followed, the operational approval should include an independent evaluation of the operators' proposed procedures. RNP APCH operating procedures should be consistent with the operator's normal procedures where possible in order to minimise any human factors elements associated with the introduction RNP operations.

15. Procedure selection and review

Operating procedures need to address the selection of the approach from the navigation database and the verification and review of the displayed data. Commonly some changes to an operator's normal practice will be involved, and the evaluation will need to recognise that new techniques may be appropriate to RNP approach operations.

In most cases the instrument approach chart will contain RNAV $_{(GNSS)}$ in the title and the clearance issued will refer to RNAV, the runway, and usually a suffix letter e.g. RNAV $_{(GNSS)}$ RWY 20 X. Due to avionics limitations the available approaches may be displayed in an abbreviated format e.g. RNVX. In some cases the suffix letters (X, Y, and Z) may not be supported. Care needs to be taken that flight crew procedures take into account these limitations and that the correct procedure is selected and then checked.

It should be recognised that the approach chart assumes less importance for an RNP APCH procedure once the procedure is loaded in the FMS and checked. During the approach only limited reference to the approach chart is normally required.

16. Use of autopilot and flight director

The manufacturer's guidance will normally provide recommendations on the use of auto-pilot and/or flight director. In general, RNP APCH procedures should be flown with autopilot coupled if the aircraft is equipped, enabling the crew to place greater attention to monitoring the approach and taking advantage of the reduced FTE normally available. This policy should not preclude the use of flight director (consistent with manufacturer procedures) when autopilot is not available or in other circumstances (e.g. OEI operations).

Note: The FTE used by the aircraft manufacturer to demonstrate RNP capability may be dependent upon the use of a coupled auto-pilot or flight director. A lesser RNP capability may be applicable to procedures flown manually using a map display.

17. GNSS updating

RNP APCH procedures are dependent on GNSS positioning, and the availability of GNSS, (as well as the available level of RNP) should be checked prior to commencement of an approach.

The failure of a GNSS receiver (i.e. an equipment failure) is commonly annunciated, but in the normal case where duplicated GNSS receivers are installed, the approach can continue normally using the serviceable receiver.

A loss of GNSS updating due to a loss of signal may occur at any time, but an alert will not normally be generated immediately. Where position integrity can be maintained following the loss of GNSS a valid position continues to be displayed.

When the required performance cannot be sustained an alert will be generated, and the normal procedure is to conduct a go-round, unless the approach can be conducted visually.
Inspectors should be familiar with the alerting system applicable to the specific aircraft under consideration to ensure that operating procedures and crew knowledge and training is consistent with the system functionality.

18. Flight crew knowledge and training

Successful RNP APCH LNAV and LNAV/VNAV approach operations depend heavily on sound flight crew knowledge and training.

The type of navigation system has a significant effect on the conduct of this type of procedure and flight training must take this factor into account.

Crews operating aircraft equipped with basic stand-alone systems typically require significantly more flight training than crews operating FMS equipped aircraft. The amount of training will vary depending on the flight crew's previous RNAV experience, however the following is provide as a guide.

Ground training. Ground training including computer-based training and classroom briefings, will normally require a minimum of one day.

Simulator training. For FMS systems operated by crews with experience in the use of the FMS for the conduct of conventional approach procedures, a pre-flight briefing session and one 2 to 4 hours simulator session per crew is commonly sufficient.

For operators of stand-alone systems, simulator or flight training may require 2 or more training sessions. Proficiency may be achieved in normal uncomplicated operations in a short period of time however additional flight time needs to be scheduled to ensure competency in the management of approach changes, go-round, holding and other functions, including due consideration of human factors. Where necessary; initial training should be supplemented by operational experience in VMC or under supervision.

19. Navigation Database

RNP APCH operations are critically dependent on valid data. The PBN Manual includes the basic requirements associated with the use and management of navigation databases.

Although the navigation database should be obtained from a qualified source, operators must also have in place sound procedures for the management of data. Experienced RNAV operators who understand the importance of reliable data will normally have such procedures established, however less experienced operators may not fully understand the need for comprehensive management procedures and may need to develop or improve existing procedures.

It should be noted that despite the requirement for the database supplier to comply with RTCA DO200A/EUROCAE document ED 76 that data errors may still occur and dependence on quality management alone is not sufficient.

Cyclic Data Updates: There is no specific requirement in the PBN Manual navigation specification to implement checks of RNP APCH approach data at each update. Despite this, operators should be encouraged to implement an electronic means of ensuring that the data loaded onto the aircraft remains valid. Although the operating tolerances for RNP APCH provide a level of conservatism, and GNSS driven approach procedures are inherently extremely accurate, electronic data errors are not in any way related to these factors and gross errors can occur just as easily as minor ones.

A cyclic comparison of new versus old data must be designed to identify changes that have not been ordered prior to the effective date for each database cycle. Action can then be taken to rectify the problem before the effective date, or issue corrective action such as notices to flight crew, withdrawal of procedures etc.,

In cases where an effective electronic cyclic data validation process is not available, it may be necessary to conduct re-validation of procedures at each cycle. This is a time-consuming and complex procedure which should be avoided wherever possible.