COSCAP South East Asia Cooperative Development of Operational Safety & Continuing Airworthiness Programme

ADVISORY CIRCULAR
FOR AIR OPERATORS

Subject: **APPROACH PROCEDURES WITH VERTICAL GUIDANCE (APV)**

Date: **Nov 2012**

Initiated By: COSCAP-SEA

AC No: **008A-APV**

1. PURPOSE

This advisory circular (AC) provides guidance for all operators conducting APV[1] approach procedures. It describes how to identify whether an approach has been designed as an APV approach; the benefits of conducting an APV approach and documents the related regulations and guidance material to be applied including some of those relating to Standard Operating Procedures (SOP) and Flight Crew Training (FCT).

Disclaimer:

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2. RELATED REGULATIONS

- *Insert State Regulations here*

3. RELATED READING MATERIAL

- FAA AC 120-108
- FAA AC 120-71A
- ICAO Doc 8168
- ICAO Doc 9613
- ICAO Doc 9849
- CASA CAAP 178-1(1)
- COSCAP AC SEA 002
- FAA-H-8261-1A
- ICAO PBN TF4 WP09 Euro Control Draft Guidance.doc
- PANS OPS, Volume I, Part II, Section 4, Chapter 1

[1] APV and precision approaches (PA) from November 2014 will be collectively described as 3D (three dimensional) approaches.

3. BACKGROUND

The 36th ICAO Assembly in 2007 passed a resolution encouraging States to implement approach procedures with vertical guidance (Baro-VNAV and/or SBAS) for all instrument runway ends, either as the primary approach or as a back-up for precision approaches by 2016. This resolution was reiterated at the 37th Assembly in 2010, where RNAV (GNSS) NPA was also recognised as an acceptable alternative where APV cannot be implemented.

APV by design incorporate CDFA concepts. The conduct of an APV approach contributes positively to situational awareness by reducing flight crew workload at a critical stage of flight. This in turn reduces the risk of Controlled Flight into Terrain (CFIT).

APV approaches are designed to provide vertical guidance to a Decision Altitude (DA). Where designed to a Decision Altitude (DA) the loss of height during the initial stage of a missed approach is taken into account.

APV approaches terminate in a visual segment and provide for a "straight-in" landing. APV approaches can provide a lower DA than precision approaches in certain circumstances; however an APV approach is not a precision approach (PA).

APV (like CDFA) procedures contribute to a stabilized approach and are characterized by a stable:

- Airspeed
- Descent rate
- Flight path

In the landing configuration to the point where the flare manoeuver begins.

An APV approach is not only safer but also:

- Improves fuel efficiency by minimizing the flight time at low altitudes
- Reduces noise levels
- Reduces the probability of infringement of the required obstacle clearance during the final approach segment

4. APPLICABILITY

This AC does **not** apply to:

- Precision approaches such as ILS, GLS, MLS
- Conventional NPA and or a LNAV / NPA.

5. OPERATIONAL PROCEDURES AND FLIGHT TECHNIQUES.

a. Equipment Requirement.

APV approaches require specific aircraft equipment. To ensure that the obstacle clearance requirements of the approach are met, the procedure must be flown within the tolerances of the navigation system on which the procedure is based. The barometric altimeter *system* must be within the manufacturers and / or operator's accuracy limits.

b. Identifying the Type of Approach

- If the IAP minimum is expressed as LNAV/VNAV (DA), LPV (DA) or RNP (DA) it means that the approach is an APV approach and that vertical guidance is provided (refer Figures 1 to 5). That is, the flight directors can be considered command instruments.
- An approach flown with flight directors acting as command instruments provides an enhanced level of safety over CDFA NPA.
- It is recommended that operators provide tailored approach charts to their flight crew clearly identifying the type of approach and the minima applicable.

Note: It is good practice to always:

- Cross check the required rate of descent required to achieve the design approach path angle. (Refer Annex Figure 2).

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

RNAV world	PBN Terminology	Chart Minima	Sensor
GPS NPA	RNP APCH down to	LNAV (MDA)	GNSS
APV Baro	RNP APCH down to	LNAV/VNAV (DA)	GNSS+ BaroVNAV/SBAS
----	RNP APCH down to (*)	LP (MDA)	GPS + SBAS
APV SBAS	RNP APCH down to (*)	LPV (DA)	GPS + SBAS

Figure 2:
Example of descent minima according to the kind of RNAV approach to be flown:

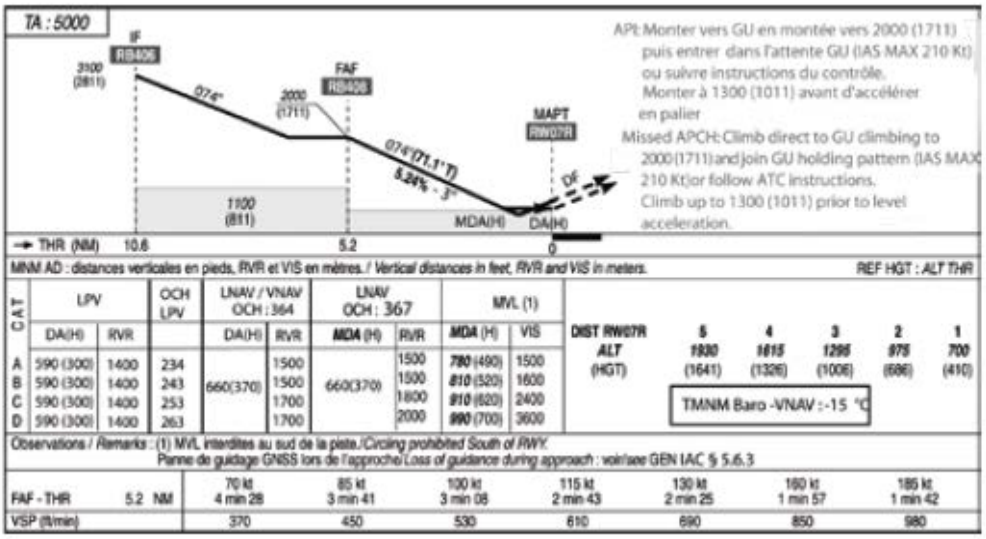


Figure 3:
Example of LNAV/VNAV minima

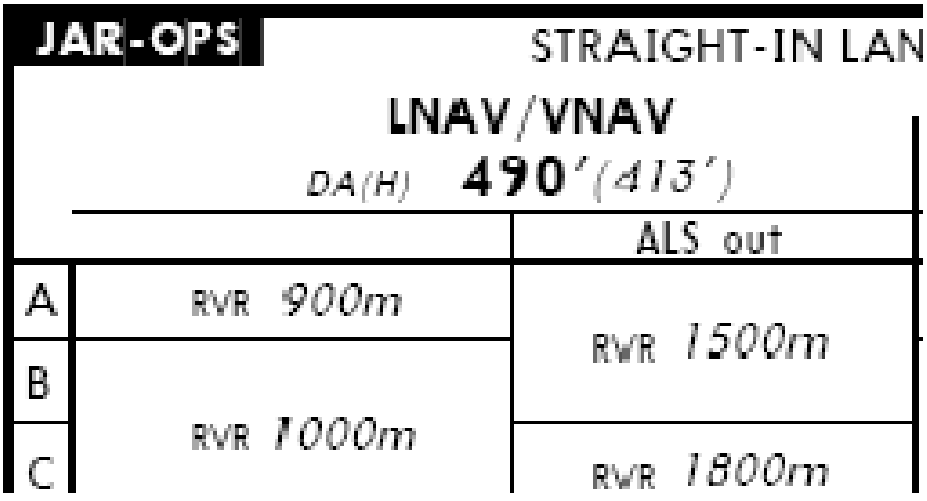


Figure 4:
Example of RNAV approach which requires Special Aircrew and Aircraft Authorisation (SAAR)

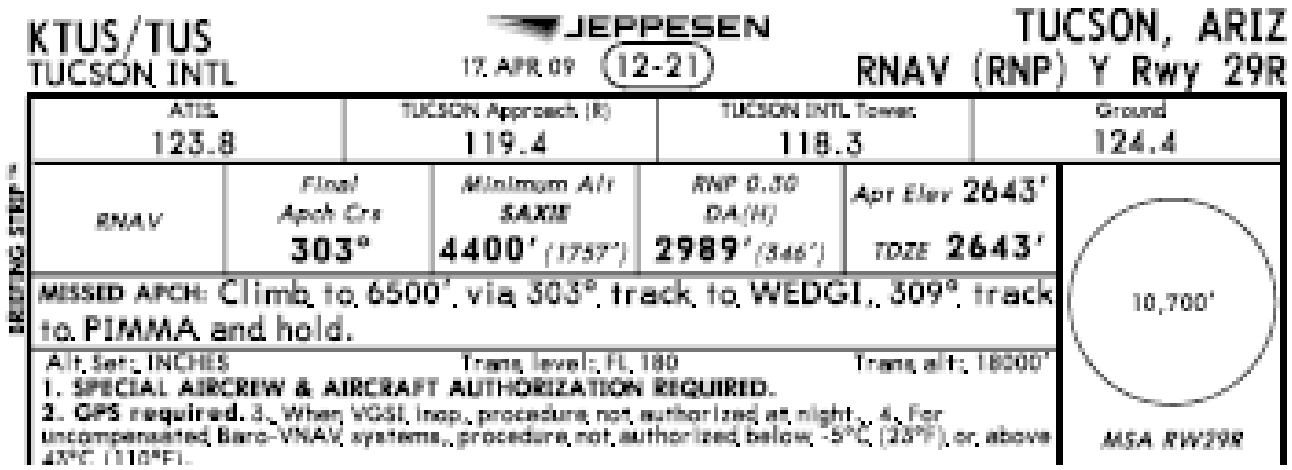
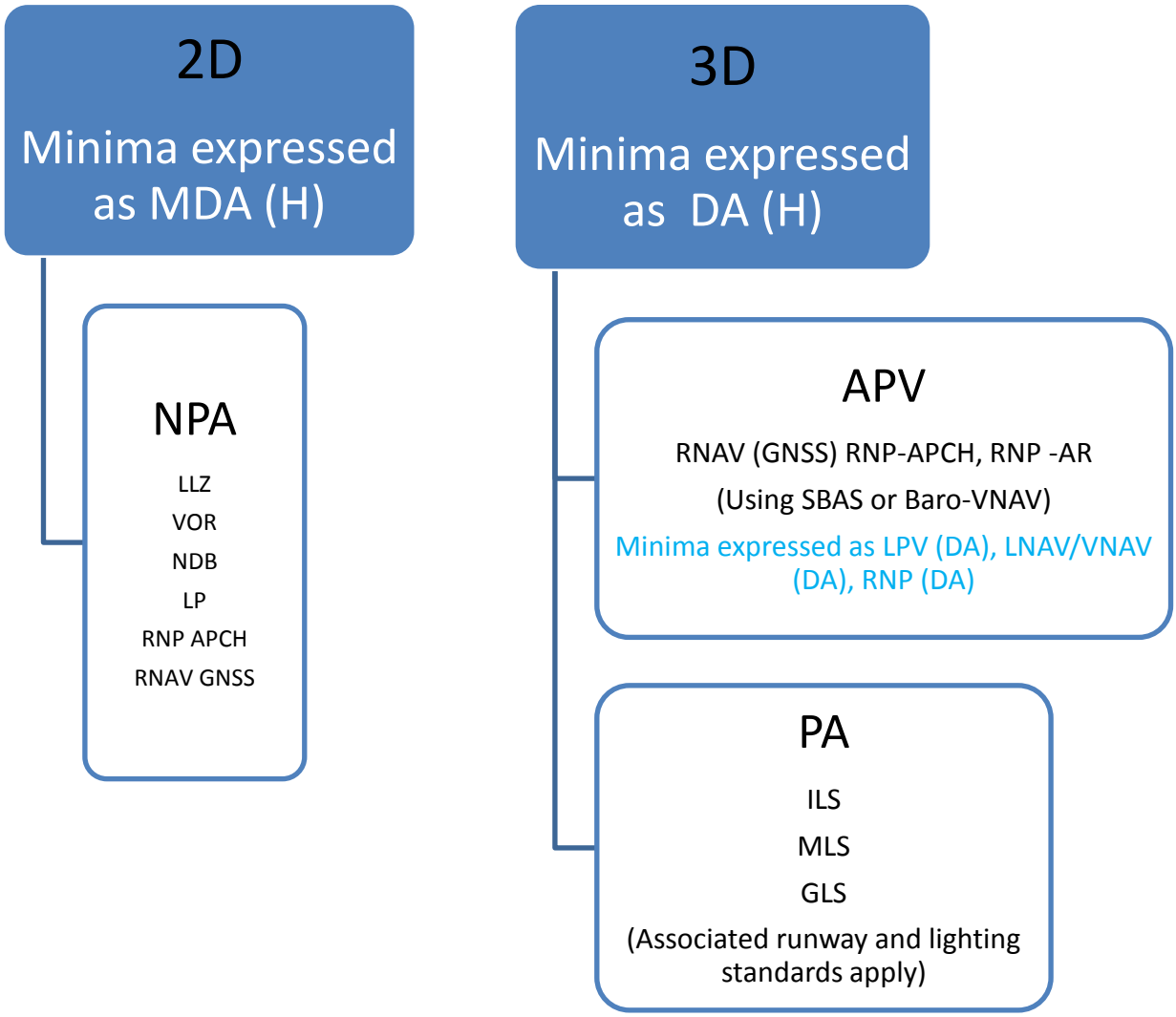


Figure 5:
ICAO Approach Classification



c. Preparation

Before commencing an APV approach the flight crew must ensure:

a) The aircraft's navigation, flight management and instrument systems have been approved for APV operations and

b) GNSS Receiver Autonomous Integrity Monitoring (RAIM) is available and verified by NOTAM or a prediction service and

c) Where required the actual navigation performance (ANP) meets the RNP standard applicable to approach being flown, and

d) The aircraft manufacturer has approved the aircraft for APV operations and the aircraft complies with the minimum equipment listed to enable the conduct of an APV approach and

e) The crew are appropriately qualified and meet all recency requirements and

f) The operator has approved the conduct of a APV approaches for the aircraft type and the aerodrome and

g) The airport meets the applicable runway and lighting standards, if any.

d. Recommended Operating Procedures

A. Lateral Navigation/ LNAV

1. GNSS or GNSS/IRS

- An APV approach must be extracted from the aircraft database. All RNAV and RNP operations are critically dependent on valid navigation data. The operator must have in place quality processes which ensure database validity. Where corrective action is required it must be taken prior to the effective date of the database or if a problem is discovered in a current database, corrective action must be taken such as issuing a Company NOTAM or withdrawal of the procedure.
- Operators should provide tailored approach charts to their flight crew which clearly identifies the type of approach and the minima applicable.
- No alterations are to be made to the database procedure between the FAP and the MAP, except to add/modify speed constraints.
- GNSS Receiver Autonomous Integrity Monitoring (RAIM) is available and the aircraft meets the RNAV or RNP standard required by the instrument approach procedure and
- Positive crew action is required when cross track deviation reaches ½ RNP for the relevant segment.
- A missed approach must be initiated when cross track deviation exceeds the RNP value for the segment.

B. Vertical Navigation/ VNAV

1. BARO

- The approach is flown to a DA.
- If an approved local QNH source is/ is not available an adjustment to the DA may be required.
- The reported temperature must be above the minimum specified on the IAP chart
- 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. Vertical deviations from the defined path shall be limited to +/-75 ft.

- 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.
    - In addition to normal SOPs it is necessary for each crewmember to independently verify the destination altimeter subscale setting
    - In addition to the existing aircraft system design features that will alert crew to some altimeter setting errors it is recommended that at least one Radio Altimeter and the EGPWS are serviceable prior to commencing any APV approach.
- Altimeter subscales can be miss-set for a variety of reasons. It is important to remember that this issue is not unique to Baro VNAV operations. Any approach which relies on barometric information for profile will be affected by a miss-set altimeter subscale.

2. Augmented GNSS[2]

- Where a Satellite Based Augmentation System (SBAS) is available and the vertical performance is in accordance with AMC 20-28 an approach to LPV (DA) can be conducted otherwise a NPA to a LP (MDA) must be made.

3. Visual

- Non-standard temperature effects and Subscale setting round down can cause offset errors from the nominal path. Flight crew must understand this effect and be aware that a lack of harmonisation with visual approach slope aids may occur, and indeed should be anticipated.
- Operators must ensure that flight crew are aware of the effects of non-standard temperatures and altimeter subscale round down.

e. Decision Altitude (DA).

At the DA, the pilot has two choices:

1. Continue the descent to land with required visual references, or
2. Execute a missed approach.

f. Executing a Missed Approach Prior to the Missed Approach Point (MAP).

When executing a missed approach prior to the MAP, unless directed otherwise by an air traffic control (ATC) instruction, fly the published missed approach procedure. This means, proceed on track to the MAP, before accomplishing a turn,

Note 1.— Guidance on the operational approval for approach and landing operations with vertical guidance using BARO-VNAV equipment can be found in the Performance Based Navigation Manual (Doc 9613), Volume II, Attachment "Barometric-VNAV".

Note 2. — For challenging obstacle environments or where tight separation requirements exist, specific procedure design criteria are available for approach and landing operations with vertical guidance. Associated operational approval guidance for RNP AR APCH operations can be found in the Performance Based Navigation Manual (Doc 9613), Volume II, Part C, Chapter 6 "Implementing RNP AR APCH."

[2] Some manufacturers claim their navigation equipment provides LNAV/VNAV capability but this may not be true if the specific GNSS augmentation system being used by the manufacturer has not yet been established in the region of operation.

g. Approach Requirement.

APV requires the use of the published, approach path angle / vertical descent angle on the Instrument Approach Procedure (IAP).

h. Computing Rate of Descent.

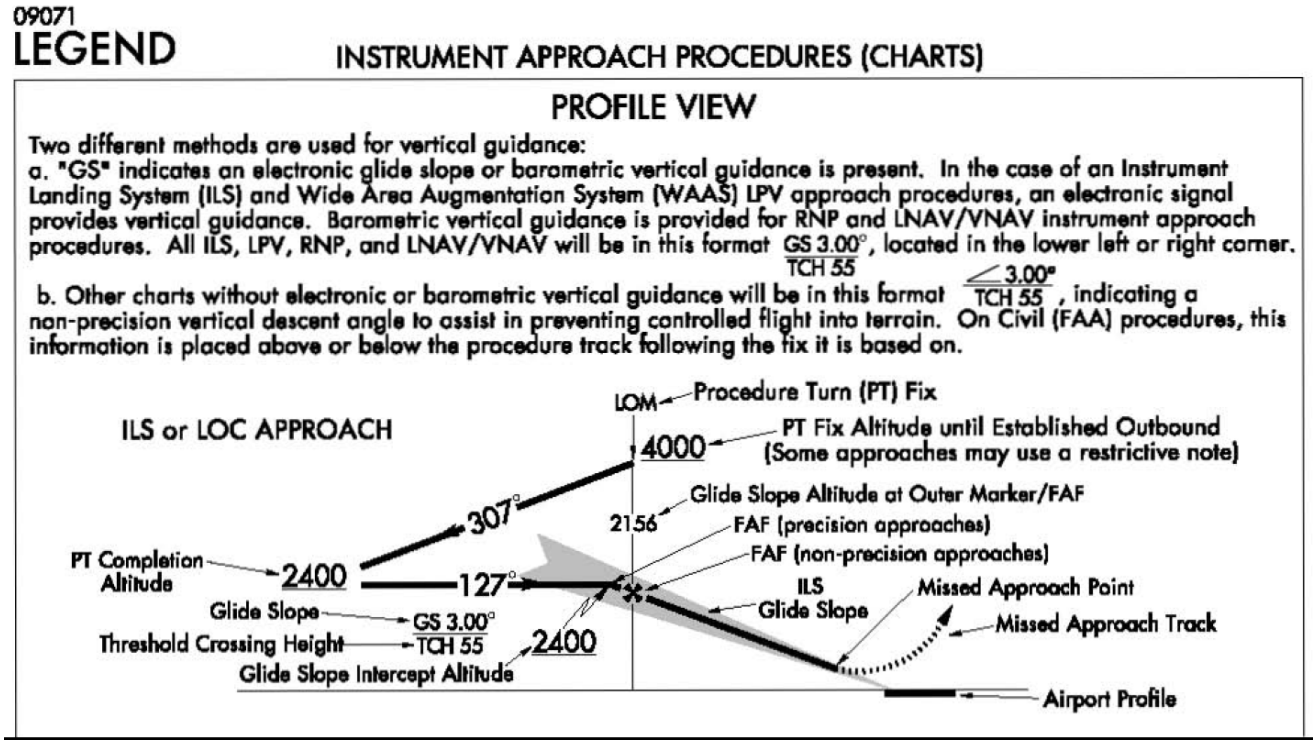
The table presented in Figure 2 to the Annex offers the flight crew a way to compute a rate of descent based on either the altitude change required per NM or the angle of descent. Knowing the rate of descent required provides a good cross check that the IAP vertical profile is being correctly flown.

6. SOP and FCT

Operators should revise their SOP and FCT as required to conduct APV operations. Operators must consult the relevant State regulations, OEM instructions and bulletins, and other advisory documents such as the FAA AC 120-71A and COSCAP AC SEA 002A to develop procedures specific to their needs. SOP and FCT should as a minimum cover the topics shown in Figure 3 of the Annex.

ANNEX

ANNEX FIGURE 1.
INSTRUMENT APPROACH PROCEDURE LEGEND



ANNEX FIGURE 2.
RATE OF DESCENT TABLE

CLIMB/DESCENT TABLE 10042

INSTRUMENT TAKEOFF OR APPROACH PROCEDURE CHARTS
RATE OF CLIMB/DESCENT TABLE
(ft. per min)

A rate of climb/descent table is provided for use in planning and executing climbs or descents under known or approximate ground speed conditions. It will be especially useful for approaches when the localizer only is used for course guidance. A best speed, power, altitude combination can be programmed which will result in a stable glide rate and altitude favorable for executing a landing if minimums exist upon breakout. Care should always be exercised so that minimum descent altitude and missed approach point are not exceeded.

CLIMB/ DESCENT ANGLE (degrees and tenths)	ft/NM	GROUND SPEED (knots)										
		60	90	120	150	180	210	240	270	300	330	360
2.0	210	210	320	425	530	635	743	850	955	1060	1165	1275
2.5	265	265	400	530	665	795	930	1060	1195	1325	1460	1590
VERTICAL PATH ANGLE 2.7	287	287	430	574	717	860	1003	1147	1290	1433	1576	1720
2.8	297	297	446	595	743	892	1041	1189	1338	1486	1635	1783
2.9	308	308	462	616	770	924	1078	1232	1386	1539	1693	1847
3.0	318	318	478	637	797	956	1115	1274	1433	1593	1752	1911
3.1	329	329	494	659	823	988	1152	1317	1481	1646	1810	1975
3.2	340	340	510	680	850	1020	1189	1359	1529	1699	1869	2039
3.3	350	350	526	701	876	1052	1227	1402	1577	1752	1927	2103
3.4	361	361	542	722	903	1083	1264	1444	1625	1805	1986	2166
3.5	370	370	555	745	930	1115	1300	1485	1670	1860	2045	2230
4.0	425	425	640	850	1065	1275	1490	1700	1915	2125	2340	2550
4.5	480	480	715	955	1195	1435	1675	1915	2150	2390	2630	2870
5.0	530	530	795	1065	1330	1595	1860	2125	2390	2660	2925	3190
5.5	585	585	880	1170	1465	1755	2050	2340	2635	2925	3220	3510
6.0	640	640	960	1275	1595	1915	2235	2555	2875	3195	3510	3830
6.5	690	690	1040	1385	1730	2075	2425	2770	3115	3460	3805	4155
7.0	745	745	1120	1490	1865	2240	2610	2985	3355	3730	4105	4475
7.5	800	800	1200	1600	2000	2400	2800	3200	3600	4000	4400	4800
8.0	855	855	1280	1710	2135	2560	2990	3415	3845	4270	4695	5125
8.5	910	910	1360	1815	2270	2725	3180	3630	4085	4540	4995	5450
9.0	960	960	1445	1925	2405	2885	3370	3850	4330	4810	5295	5775
9.5	1015	1015	1525	2035	2540	3050	3560	4065	4575	5085	5590	6100
10.0	1070	1070	1605	2145	2680	3215	3750	4285	4820	5355	5890	6430

ANNEX FIGURE 3.

SOP and FCT to Support APV

The following topics should be included in (but not limited to) an operator's SOP and / or FCT as required to support APV operations. This is not a prescriptive list. Operators must consult the relevant State, OEM, and other advisory documents to develop standard operating procedures and training programs specific to their operation.

Automation
1) The automation use philosophy
2) Requirements or limitations on coupling the autopilot to flight guidance systems
3) Use of automation as appropriate to the task
4) Flight Management Systems/ Flight Director/ Autopilot: interaction; degradations; reversions
5) Monitoring of automated systems and Flight Mode Annunciator (FMA) changes and alerts
Altimetry
1) Altitude awareness-situation awareness
2) Determination of Minimum Safe Altitudes (MSA) and Minimum Descent Altitudes (MDA)
3) Use of an appropriate, current and accurate barometric subscale
4) Transition level and international differences
5) Altitude awareness crew callouts / auto callouts
6) Components of total altimeter system error
7) Corrections for wind and temperature
8) Monitoring rate of climb / descent during last 1000 feet of altitude change
9) Use of radio altimeter
10) Metric operations
Contingencies
1) The effect of failures on an aircraft's navigation capability
2) The effect of system failures on the operating minima/aircraft approach capability
3) Procedure to recover from automation failure
4) Reversion to basic modes of operation
Human Factors
1) Managing ATC as a 'crew resource'
2) Cross checking FMS routing with ATC clearance
3) Timely conduct of approach briefing
4) Briefing to include:
a. Location specific CFIT risk stated / addressed
b. Location specific crew qualification considered
c. Altimeter corrections considered
d. Avoidance of rushed approaches
e. Statement of the expected descent and approach profile (gradient)
f. Statement of the expected meteorological conditions
g. Statement of the expected aircraft configuration
h. Expected aircraft heading and attitude at MDA
i. Approach monitoring philosophy
j. Actions and callouts when approach 'gates' are missed
5) Go-around / missed approach actions
6) Aircraft clean-up profile
7) Flight deck discipline
8) PF/PNF duties and responsibilities

9) Sterile cockpit
10) Maintaining vigilance – situational awareness
11) Monitoring / cross-checking
Legal
1) Flight planning requirements applicable to CDFA operations
2) Crew qualification
3) Aircraft approach capability
4) Navigation authorization
5) Appropriate operating clearances
6) Airport capability
Navigation
1) The capability and limitation of the aircraft's navigation system
2) Accurate interpretation of approach chart pictorial and textual navigation requirements.
3) Approach procedure design criteria
4) International differences in chart design: PANS OPS, TERPS,
5) The type of operation and airspace classes for which the navigation system is approved
6) Functional integration of navigation system with other aircraft systems
7) Verification that the navigation system self- tests satisfactorily
8) Verification that the aircraft navigation data is current
9) Initialization
10) Verification of the accuracy of the navigation system
11) Fly direct to/ intercept a track / accept vectoring/ rejoin approach procedure
12) De-selection / re-selection of navigation aids
13) Perform gross navigation error checks using conventional navigation aids
14) The effect of bank angle restrictions on an aircraft's navigation capability
15) Contingency procedures for navigation system failures
16) Components of total system error
17) Determination of cross-track error / deviation
18) Position update logic and priority
Operations
1) A minimum of one four hour simulator session is required
2) Demonstrated ability to fly a stabilized approach
3) The requirement to observe the speed constraints in radius to fix (RF) legs
4) Fly the appropriate engine inoperative airspeed to allow compliance with bank angle limits
5) The appropriate use of auto-thrust / manual thrust to manage airspeed
6) The use of aircraft radar, TAWS, EGPWS, or other avionics systems to support the flight crew's track monitoring and weather and obstacle avoidance.
7) Correct interpretation of electronic displays and symbols on flight and navigation display
8) The effect of altitude, wind and groundspeed on aircraft performance
9) The go-around procedure and the flight modes required
10) Appropriate aircraft configuration to allow compliance with bank angle or speed restrictions during the approach or missed approach.
11) The effect of activating TOGA while in a turn
12) Appropriate response to the loss of GNSS during a procedure
13) Performance issues associated with reversion to radio updating and limitations on the use of DME and VOR updating

ANNEX FIGURE 4
GLOSSARY of TERMS

APV – Approach Procedure with Vertical guidance. This term is used for RNP APCH operations that include vertical guidance. That is, those flown to LNAV/VNAV or LPV minima. Does not meet the requirements established for precision approach and landing operations

APV Baro[3] - An approach (including RNP Approach) with barometric vertical guidance flown to the LNAV/VNAV DA/H.

APV SBAS is supported by Satellite Based Augmentation Systems such as WAAS in the US and EGNOS in Europe to provide lateral and vertical guidance. The lateral guidance is equivalent to an ILS localizer and the vertical guidance is provided against a geometrical path in space rather than a barometric altitude. RNAV (GNSS) approach to LP minima is also supported by SBAS.

APV SBAS - An approach (including an RNP approach) with geometric vertical guidance flown to the LPV DA/H

Baro/VNAV – An on-board functionality where the Barometric Altimeter is part of an integrated Air Data System connected to the flight management computer. It computes vertical guidance relative to a computed profile.

CDFA – Continuous Descent Final Approach. A flying technique where a continuous descent is made along a predefined vertical path.

DA/H – Decision Altitude (Height) as used on a precision approach and an APV.

EGNOS – The European Geostationary Navigation Overlay Service. This is the European SBAS System.

GPS NPA - An RNP APCH flown to LNAV minima.

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.

LNAV Lateral Navigation

LNAV, **LNAV/VNAV**, **LPV** and **LP** are the minima lines on the chart. The minima line to be used depends on the aircraft capability and approval.

LNAV - the minima line to be flown on aircraft with no VNAV approval. LNAV approval is according to AMC 20-27.

LNAV/VNAV – the minima line to be flown if the aircraft has an approved Baro/VNAV system approved according to AMC 20-27

LPV – Localizer Performance with Vertical Guidance- the minima line to be flown if the aircraft has SBAS capability approved according to AMC 20-28

LP – Localizer Performance-The minima line to be flown by SBAS capable aircraft where the vertical performance is not good enough to support LPV operations.

MDA/H – Minimum Descent Altitude (Height) as used on a Non Precision Approach.

NPA – Non Precision Approach. An approach procedure without vertical guidance. Could be based on conventional navigation aids or RNAV. See GPS NPA above.

NPA - an approach without vertical guidance flown to the LNAV or the LP MDA/H.

PBN – Performance Based Navigation

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 ground based navigation aids. APV and RNP APCH procedures are types of RNAV approach.

RNP AR APCH -An approach which requires special operational approval. Such procedures are useful in terrain rich environments.

RNP APCH - This is the terminology used in the ICAO PBN Manual [Doc 9613

RNP – Required Navigation Performance

SBAS – Satellite Based Augmentation System – The European SBAS is called EGNOS. The US version is called WAAS.

VNAV Vertical Navigation

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[3] *ICAO APV Baro procedure design criteria now allow the use of SBAS for vertical guidance. This shall however be explicitly approved by the publishing ANSP before such an operation can be conducted.*