Implementing Baro-VNAV

PHILIPPINE Experience

APAC FPP Procedure Design Seminar

17-19 September 2019

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CIVIL AVIATION AUTHORITY OF THE PHILIPPINES

A BIT OF HISTORY

A36-23: ICAO 36th Assembly endorses PBN implementation (2007)

"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 and planning and implementation regional groups (PIRGs) complete a **PBN implementation plan** by 2009 to achieve:*

2) implementation of approach procedures with vertical guidance (APV) (Baro-VNAV and/or augmented GNSS) for all instrument runway ends, either as the primary approach or as back-up for precision approaches by 2016 …"

A BIT OF HISTORY

A37-11: Modification of A36-23 (2010)

"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:

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 back-up for precision approaches by 2016 …"

IMPLEMENTING PBN IN AIRPORTS

Strategy of improving airport accessibility through development of instrument flight procedures to:

-improve safety/airport accessibility

-meet the ICAO Assembly Resolution A37-11 and APAC Seamless ATM Plan

- **PBN in International Airports: 2010-2016**

  Available in 9 International Airports

  -Back-up to existing ground-based procedure (ILS and VOR) during outages, maintenance

- **PBN in Domestic Airports: 2012-2019**

  -Available in 9 Domestic airports

  -Reduce CFITs/increase airport accessibility

- **PBN in Non-Instrument Runways: 2019-**

  -improve safety

IMPLEMENTING APV/LNAV-VNAV

Approach with vertical guidance (APV)

An instrument approach procedure which utilizes lateral and vertical guidance but does not meet the requirements established for precision approach and landing operations

Barometrical vertical navigation (baro-VNAV) is a navigation system that presents to the pilot computed vertical guidance referenced to a specified vertical path angle (VPA).

IMPLEMENTING APV/LNAV-VNAV

III-3-4.7 PROMULGATION (Doc 8168 Vol II)

a) OCA/H

b) RDH

c) VPA

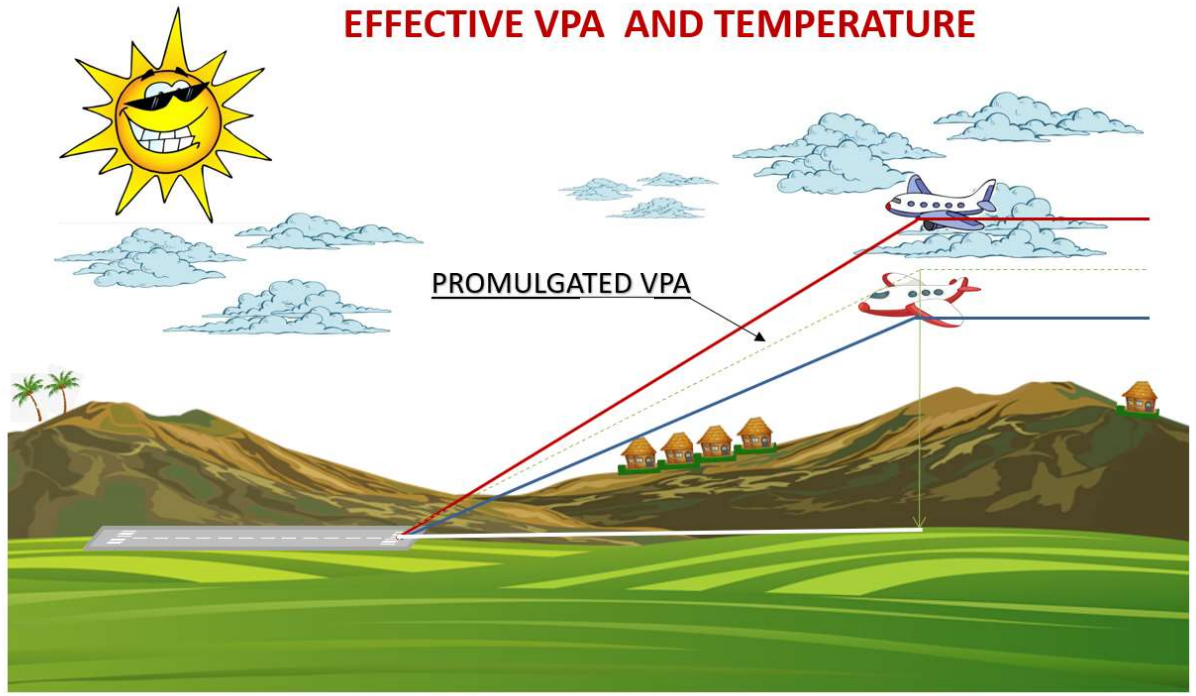
d) Minimum temperature for which APV/Baro-VNAV operations are authorized

e) Temperature above which EFFECTIVE VPA will exceed 3.5°; and,

f) LNAV FAF and MAPt *(for database coding purposes only)*

TEMPERATURE LIMITATIONS

"Minimum temperature for which APV/Baro-VNAV operations are authorized."

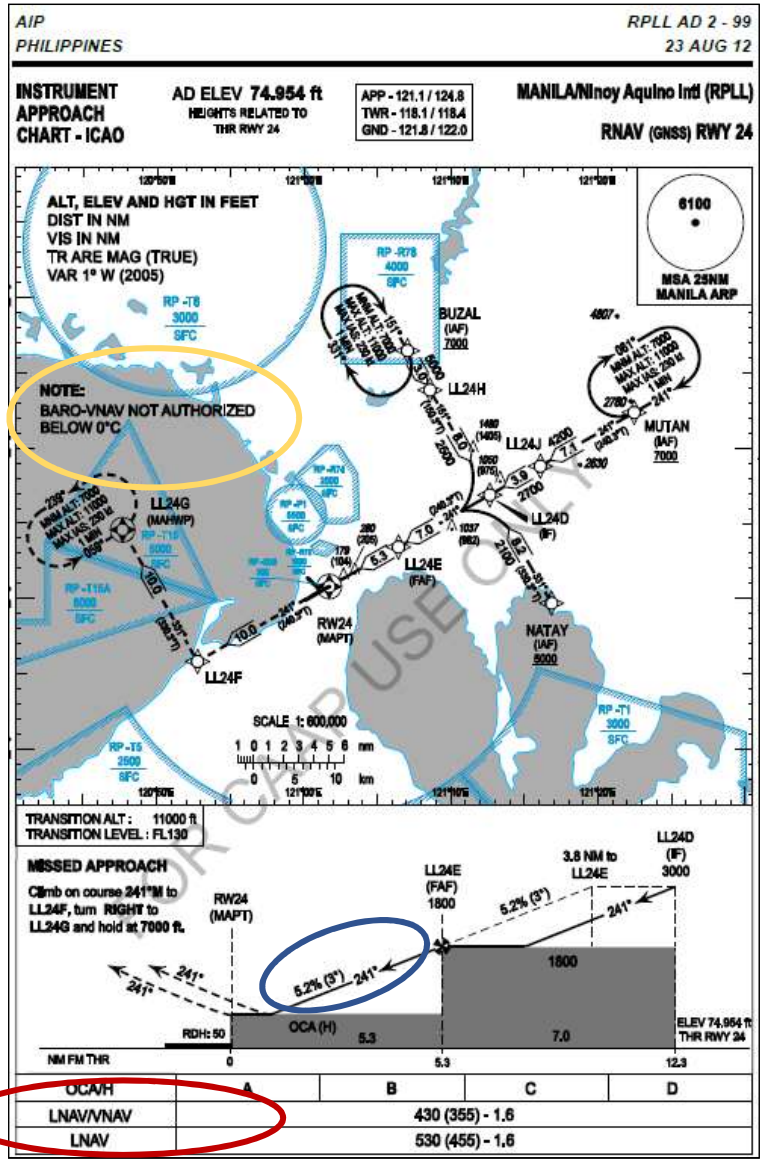


$$TAN_{MIN/MAX\ VPA} = (Height\ FAP - T_{CORR} - RDH)/D_{FAP\ THR}$$

COLD temperature **reduces** vertical path angle

HIGH temperature **increases** vertical path angle

IMPLEMENTING APV/LNAVVNAV



I. **Promulgating MIN TEMPERATURE**

Mean Low temperature

Coldest month of the year

Last 5 years

Round down to the next 5-10 increments

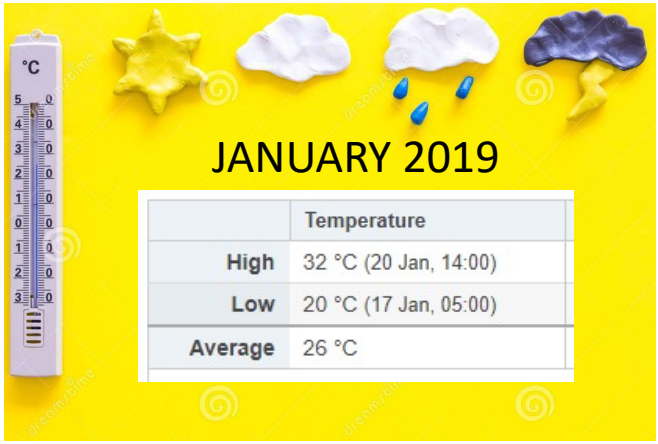


Table III-3-4-1. Effective vs promulgated VPA as a function of aerodrome elevation and temperature (Green = optimum; Yellow = non-standard; Orange = prohibited)

Temp (C°)	Promulgated VPA 2.8°			Promulgated VPA 3.0°			Promulgated VPA 3.2°		
	Aerodrome elevation			Aerodrome elevation			Aerodrome elevation		
	MSL	3 000 ft	6 000 ft	MSL	3 000 ft	6 000 ft	MSL	3 000 ft	6 000 ft
50	3.14	3.21	3.28	3.37	3.44	3.51	3.59	3.67	3.75
40	3.05	3.11	3.18	3.26	3.33	3.40	3.48	3.55	3.63
30	2.95	3.01	3.07	3.16	3.22	3.29	3.37	3.44	3.51
20	2.85	2.91	2.97	3.05	3.12	3.18	3.26	3.32	3.40
10	2.75	2.81	2.87	2.95	3.01	3.07	3.14	3.21	3.28
0	2.65	2.71	2.77	2.84	2.90	2.96	3.03	3.10	3.16
-10	2.55	2.61	2.66	2.74	2.79	2.85	2.92	2.98	3.04
-20	2.46	2.51	2.56	2.63	2.69	2.74	2.81	2.87	2.93
-30	2.36	2.41	2.46	2.53	2.58	2.63	2.70	2.75	2.81
-40	2.26	2.31	2.36	2.42	2.47	2.53	2.58	2.64	2.70
-50	2.16	2.21	2.26	2.32	2.36	2.42	2.47	2.52	2.58

EFFECTIVE and PROMULGATED VPA

EFFECTIVE VPA- temperature and aerodrome elevation dependent

PROMULGATED VPA -effective VPA throughout the year is as close as possible to 3.0°

Table III-3-4-1. Effective vs promulgated VPA as a function of aerodrome elevation and temperature (Green = optimum; Yellow = non-standard; Orange = prohibited)

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30	2.95	3.01	3.07	3.16	3.22	3.29	3.37	3.44	3.51
20	2.85	2.91	2.97	3.05	3.12	3.18	3.26	3.32	3.40
10	2.75	2.81	2.87	2.95	3.01	3.07	3.14	3.21	3.28
0	2.65	2.71	2.77	2.84	2.90	2.96	3.03	3.10	3.16
-10	2.55	2.61	2.66	2.74	2.79	2.85	2.92	2.98	3.04
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-30	2.36	2.41	2.46	2.53	2.58	2.63	2.70	2.75	2.81
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-50	2.16	2.21	2.26	2.32	2.36	2.42	2.47	2.52	2.58

PROMULGATED VPA is the LNAV descent gradient.

Consideration of obstacle clearance on final

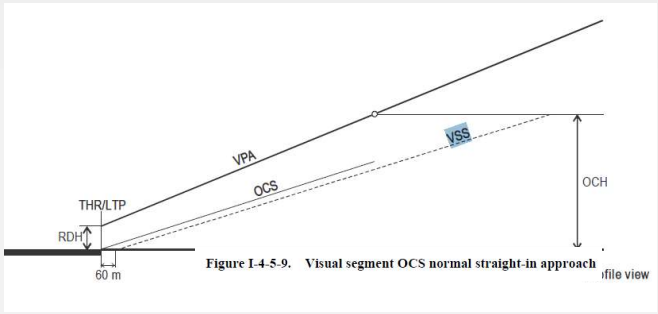
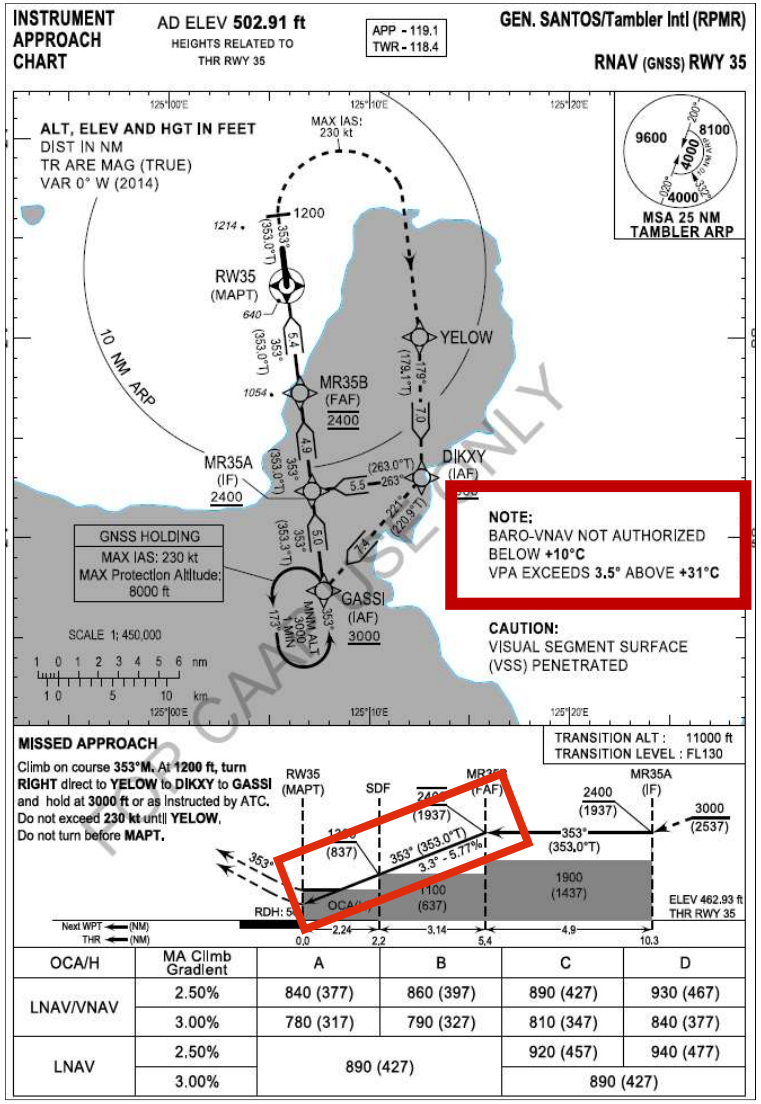


Figure I-4-5-9. Visual segment OCS normal straight-in approach

Effect of TEMPERATURE on the IAP with STEEP SLOPE: 3.3°



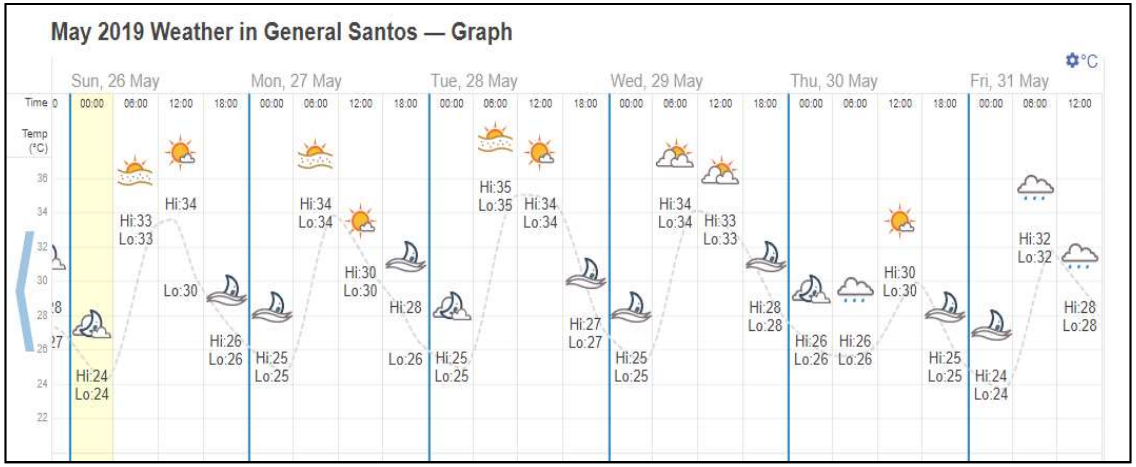
OCA/H	MA Climb Gradient	A	B	C	D
LNAV/VNAV	2.50%	840 (377)	860 (397)	890 (427)	930 (467)
	3.00%	780 (317)	790 (327)	810 (347)	840 (377)
LNAV	2.50%	890 (427)		920 (457)	940 (477)
	3.00%			890 (427)	

ISA + 30

Minimum Temperature: +10°

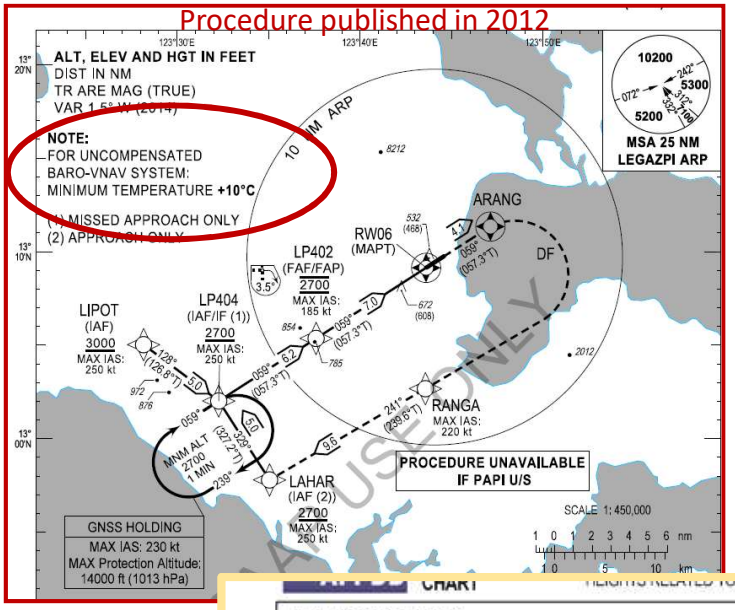
Maximum Temperature: +31°

Promulgated VPA = LNAV descent gradient



	Temperature
High	35 °C (28 May, 11:00)
Low	23 °C (10 May, 05:00)
Average	28 °C

Effect of TEMPERATURE on IAP with STEEP SLOPE: 3.5°



TEMPERATURE CORRECTION (MINIMUM & MAXIMUM)

MIN +10° C

ΔT_{STD} = (273.15+10) – (-0.0065x18.027) – 288.15 = -4.8828m

Δh = - (-4.8828/-0.0065) x ln [1+ (-0.0065x804.93/ 288.15- (0.0065x18.027))] = 13.80m

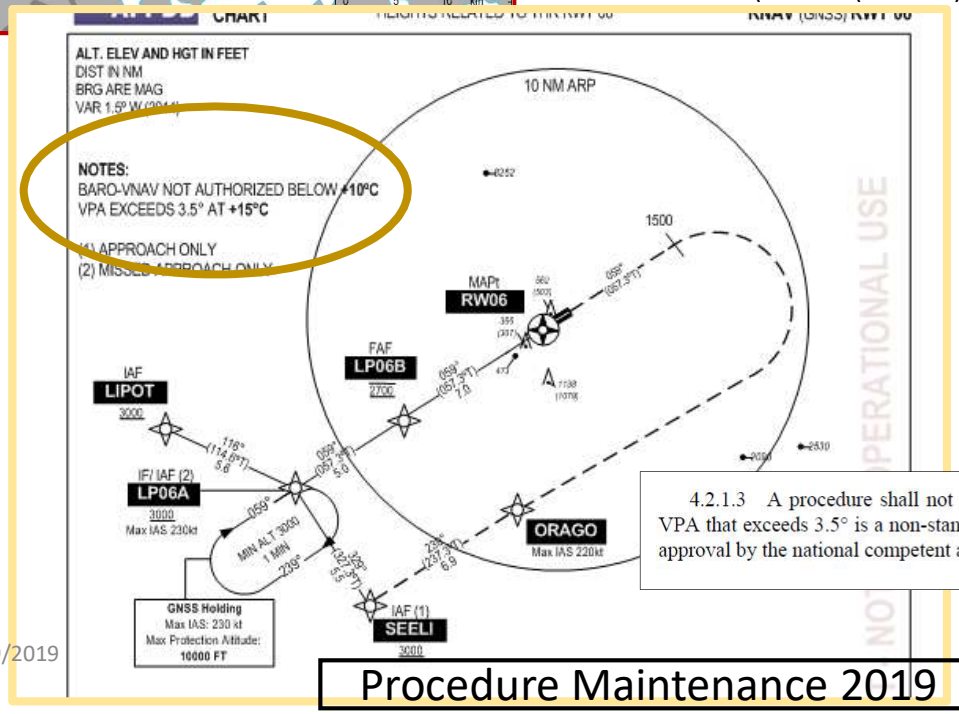
tan Min VPA = (804.93-13.80-15) / 12912 = 0.0601 ≈ **3.44°**

MAX +15°C

ΔT_{STD} = (273.15+15) – (-0.0065x18.027) – 288.15 = 0.1172

Δh = - (0.1172/-0.0065) x ln [1+ (-0.0065x804.93 / 288.15-0.0065x18.027)] = -0.3312m

tan Max VPA = (804.93-(-0.3312)-15) / 12912 = 0.0612 ≈ **3.502°**



Procedure Maintenance 2019

	Temperature
High	31 °C (11 Jan, 14:00)
Low	22 °C (29 Jan, 05:00)
Average	26 °C

BARO-VNAV Approach:
Effective VPA always more than 3.5° (MAX)

4.2.1.3 A procedure shall not have a promulgated VPA that is less than 2.5°. A procedure with a promulgated VPA that exceeds 3.5° is a non-standard procedure. It shall be subject to an aeronautical study and will require special approval by the national competent authority (see Part I, Section 4, Chapter 5, 5.3.1.2 and Appendix B to Chapter 5).

OTHER CONSIDERATIONS

1. HL Correction for Steep Glide Path>3.2

   TABLE III-3-6-3.Height Loss/Altimeter margin

   HLr x (5/100) x [VPA-3.2)/0.1]

2. **ORIGIN OF MISSED APPROACH** Xz (-900,-1100,-1400)m

Due to VPA above 3.2°:

Xz Cat A = min [-900, (41-15)/tan3.3 – (444+2x56xsin3.3/0.78x(56+5.15))]

Cat B = min [-900, (44-15)/tan3.3 – (444+2x72xsin3.3/0.78x(72+5.15))]

Cat C = min [-1100, (48-15)/tan3.3 – (444+2x89xsin3.3/0.78x(89+5.15))]

Cat D = min [-1400, (51-15)/tan3.3 – (444+2x104xsin3.3/0.78x(104+5.15))]

SOME POINTS TO CONSIDER

1) OCA/H of Baro-VNAV lower than LNAV.

2) Publication of MINIMUM TEMPERATURE should be a case to case basis.

Promulgated VPA= 3°	3.3°	3.5°
Min TEMP ≤2.5° = -30°C	-50°	-60°
Max TEMP ≥3.5° = +62°C	+31°C	+15°C

3) IF the effective VPA is expected to be >3.5°, require special approval? Let the pilot decide? Promulgate the procedure in a different chart?


Designed by Pngtree

MINIMUM SECTOR ALTITUDES (MSA)

PAN-OPS Vol II I-4.8

DEFINITION: The lowest altitude which may be used which will provide a minimum clearance of 300 m (1000 ft) above all objects located in an area contained within a sector of a circle of 46 km (25NM) radius centered on a significant point, the aerodrome reference point (ARP) or the heliport reference point.

-mandatory for IAPs

-to be provided in ARRIVAL ROUTES where TAAs are not provided

-MOC increased in mountainous areas

-at least 300 ft difference between two adjacent sectors

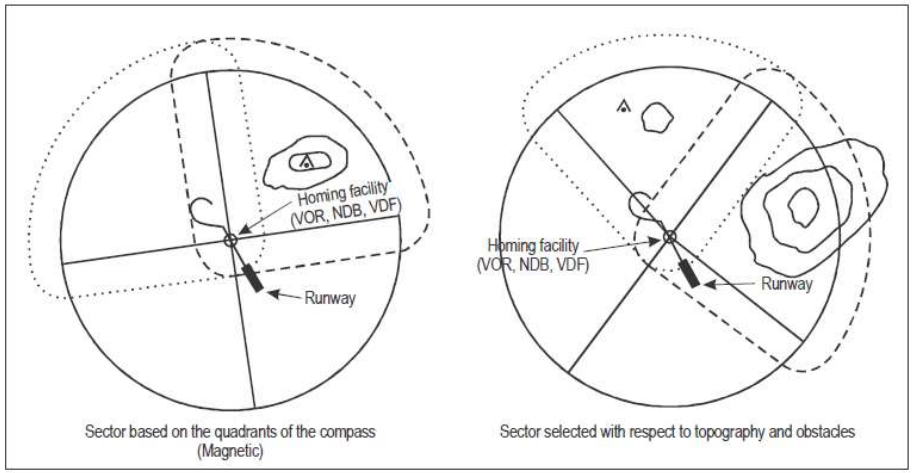
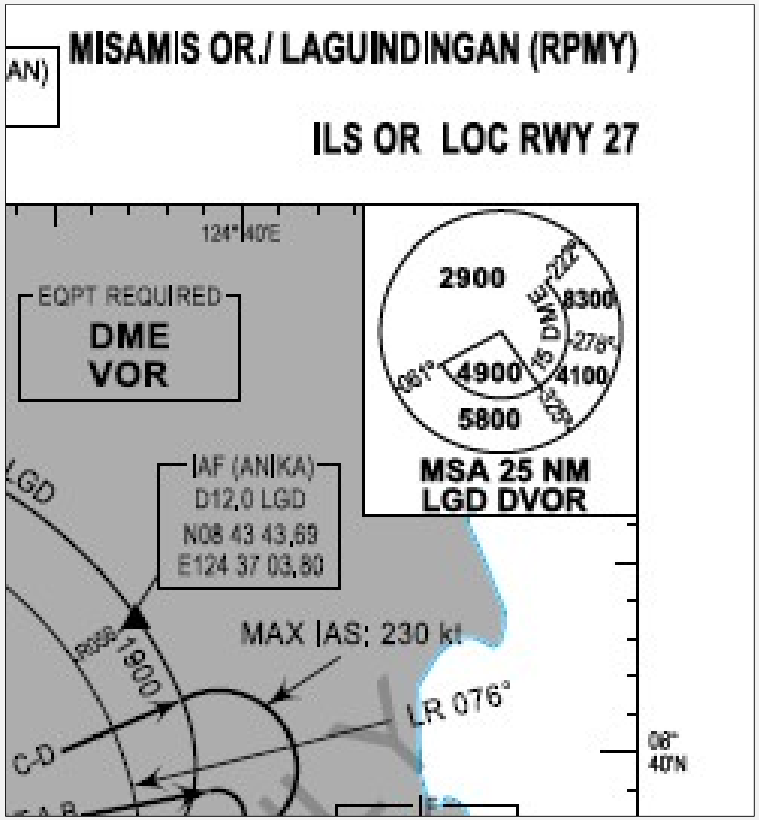


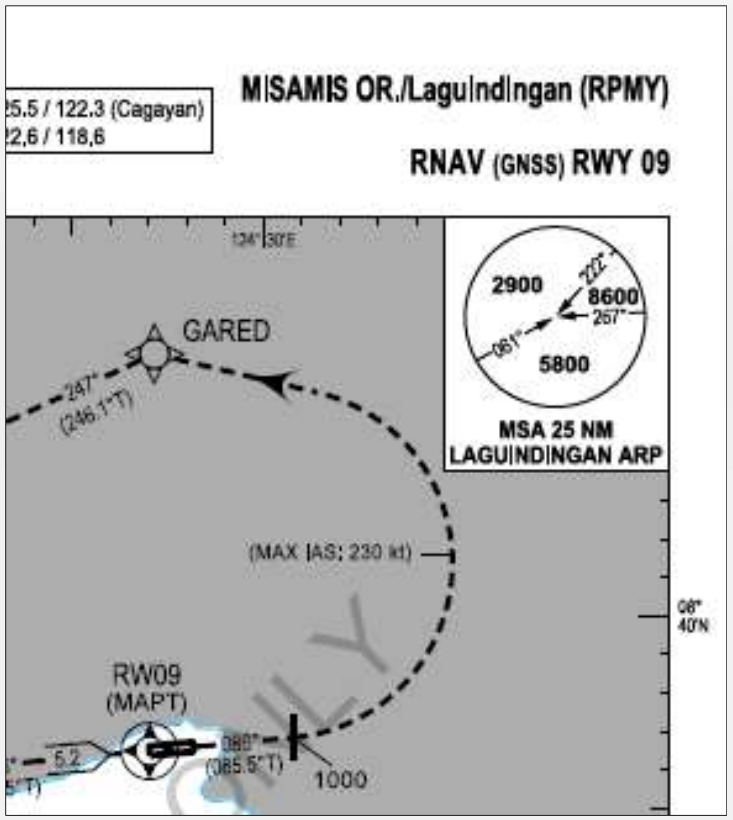
Figure I-4-8-1. Sector orientation

MINIMUM SECTOR ALTITUDES (MSA)

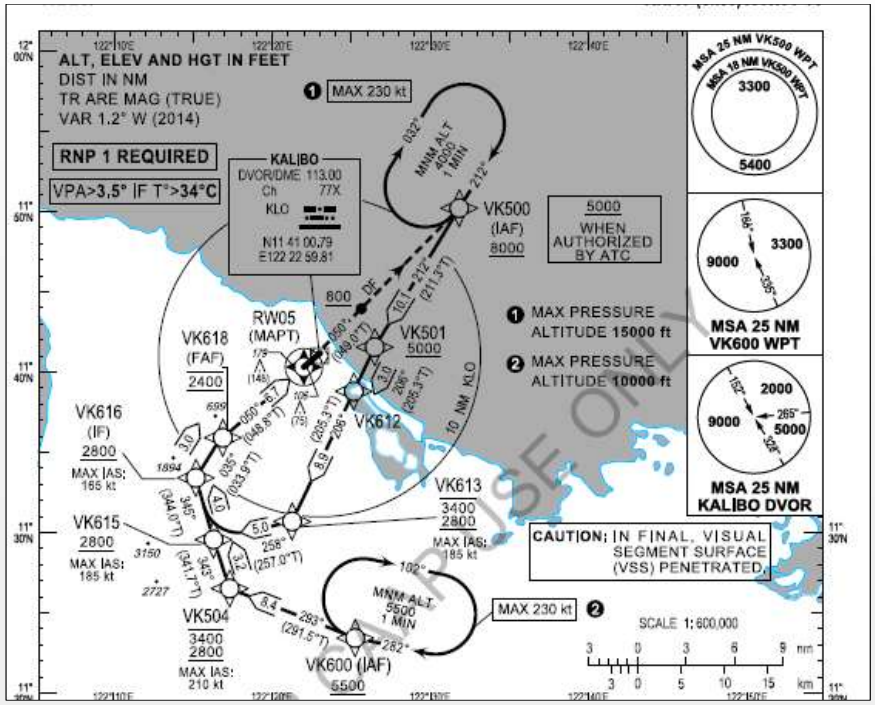
Conventional procedure centered on VOR/DME

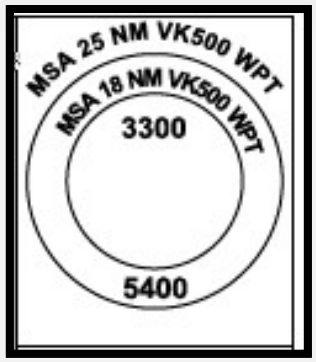


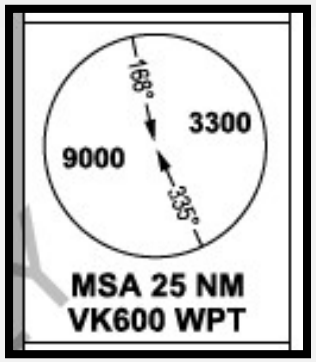
PBN procedures centered on the ARP



MSA in terrain challenged airports



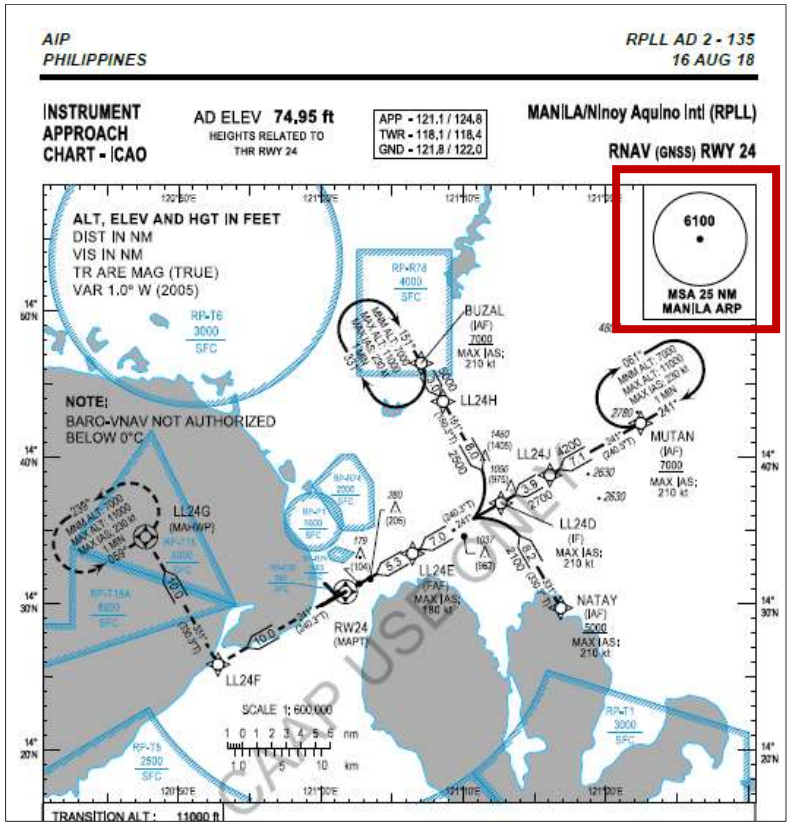




centered on a significant point

requires nav aid

MINIMUM SECTOR ALTITUDES (MSA)



-Found in most RNP APCH charts elsewhere

- Preferred by some pilots as it would be difficult to determine a radial or track to a point (ARP) if it is going to a different point (IAF) or to determine the distance from a point.

-For ATCs, little benefit to facilitate descent in some complex environment

-TAA Stepdown Arcs and subsectors

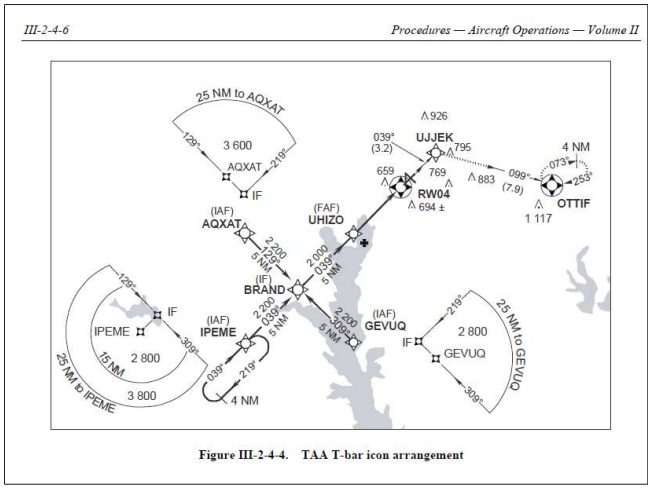


Figure III-2-4-4. TAA T-bar icon arrangement

MINIMUM SECTOR ALTITUDES (MSA)

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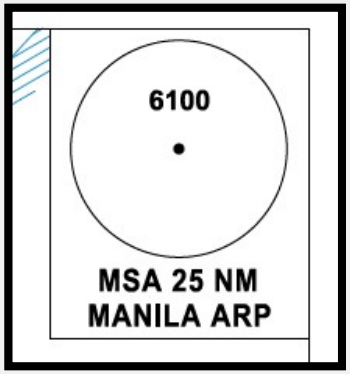
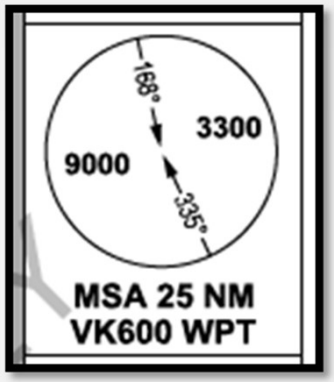
FOR PBN:

WHAT COULD BE THE MOST APPROPRIATE?



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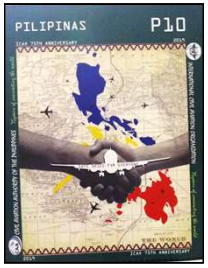
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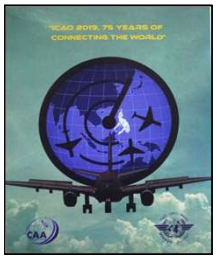
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