

**Organización de Aviación Civil Internacional
Oficina Regional Norte América, Centro América y el
Caribe (NACC)**



**TALLER SOBRE DISEÑO DE PROCEDIMIENTOS DE
APROXIMACION DE NAVEGACION BASADA EN
LA PERFORMANCE (PBN)**

RNP BARO-VNAV (LNAV/VNAV) APPROACHES.

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Summary

- General.
- APV segment.
- APV OAS.
- Temperature Correction.
- Obstacles assesment.
- Determination of OCH.

General

- Baro-VNAV approach procedures are classified as APV procedures in support of Type A 3D approach operations.
- The vertical segment is based on barometric altitudes.
- Baro-VNAV procedures are used in association with LNAV-only procedures. The LNAV-only FAF and MAPt are needed to define the lateral areas and to support the lateral guidance but they are not used for the Vertical Navigation function.
- They use a FAP and DA/H (no MDA/H is used).
- Baro-VNAV procedures shall not be authorized with a remote altimeter setting.
- They use obstacle assessment surfaces similar to those for ILS, but based on the specific lateral guidance system.

APV Segment

- The APV segment contains the final descent segment for landing, and the initial and intermediate segments of the missed approach. It shall be aligned with the extended runway centre line. A turn at the FAF of up to 15° is allowed.
- The optimum VPA is 3°, it shall not be less than 2.5° or greater than 3.5° for the prevailing temperature.
- The APV OAS starts at the final approach point (FAP), and should not be located more than 19 km (10 NM) before the threshold.

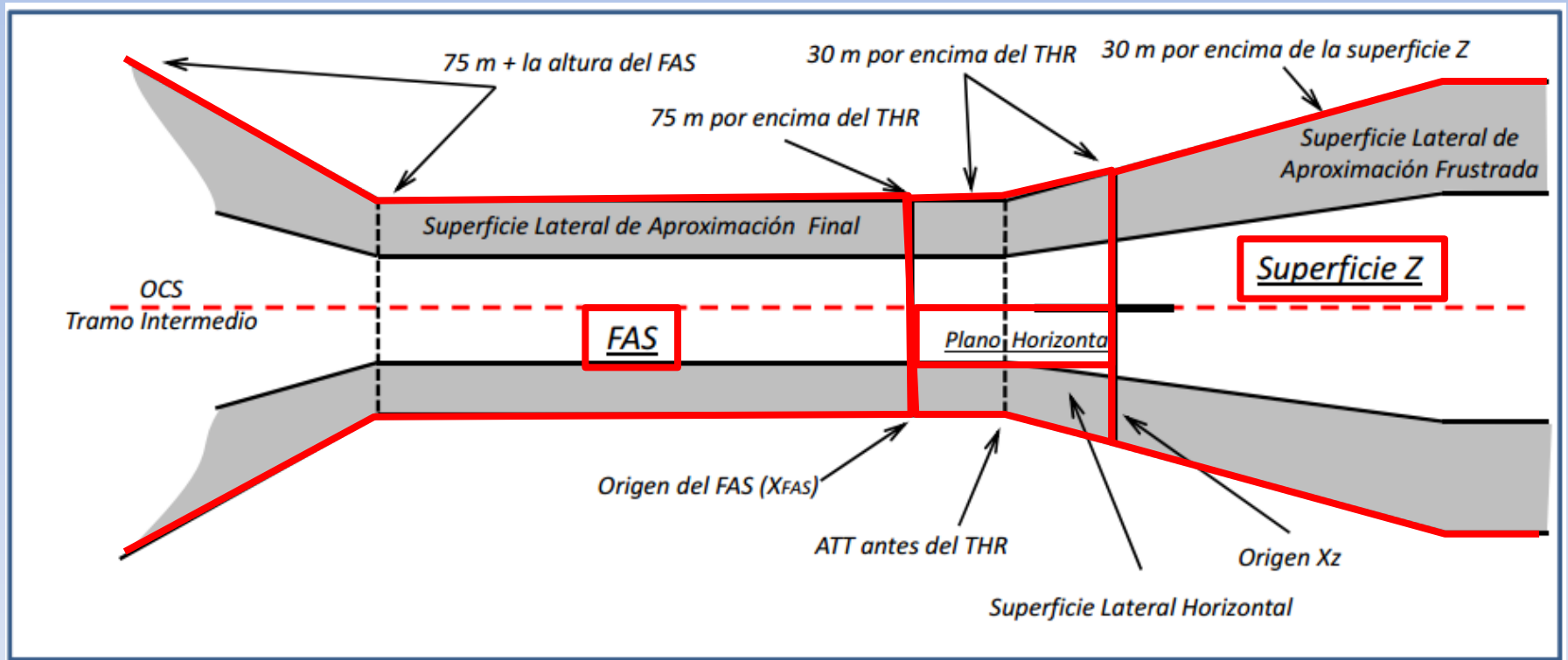
OAS APV

The OAS are used to identify accountable obstacles and consist of the following surfaces:

- a) final approach surface (FAS);
- b) ground plane; and
- c) missed approach surface (Z surface).

The final approach surface is bounded laterally by the edges of the LNAV primary area. The upper/outer edges of the APV-OAS side surfaces are laterally coincident with the outer edges of the LNAV secondary areas.

Superficies de evaluación de obstáculos



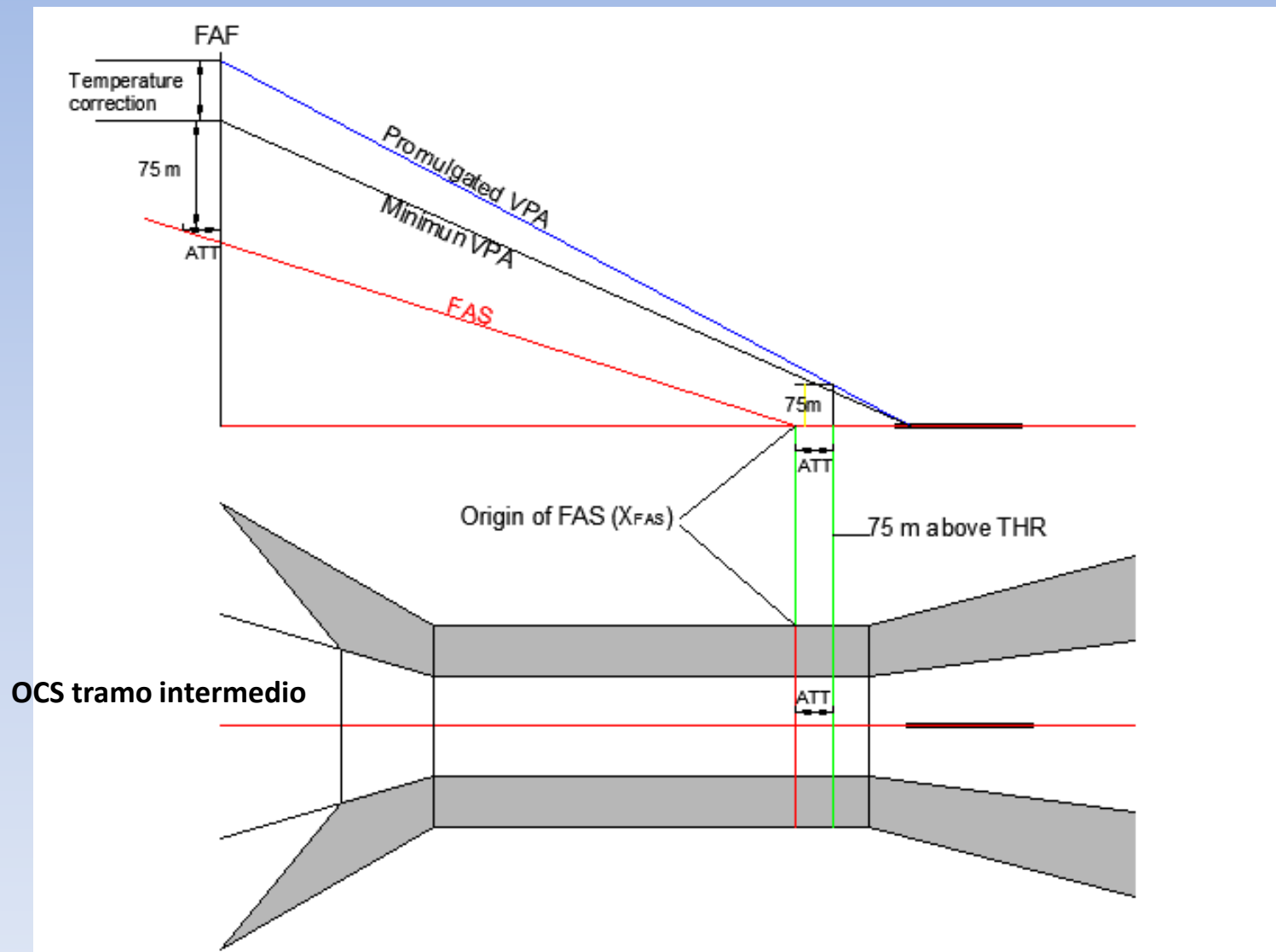
OAS APV

Final approach surface. The origin of the final approach surface (FAS) is at threshold level and is located at a distance of 444 m (ATT) prior to the point where the promulgated vertical path reaches a specified height above the threshold and extends up to the intersection with the horizontal OCS of the intermediate segment.

The value of H_i is as follows:

- a) $H_0 = 75$ m below 5 000' AMSL,
- b) $H_{5000} = 105$ m between 5 000' and 10 000' AMSL and
- c) $H_{10000} = 120$ m at or above 10 000' AMSL.

Superficie de aproximación final (FAS)

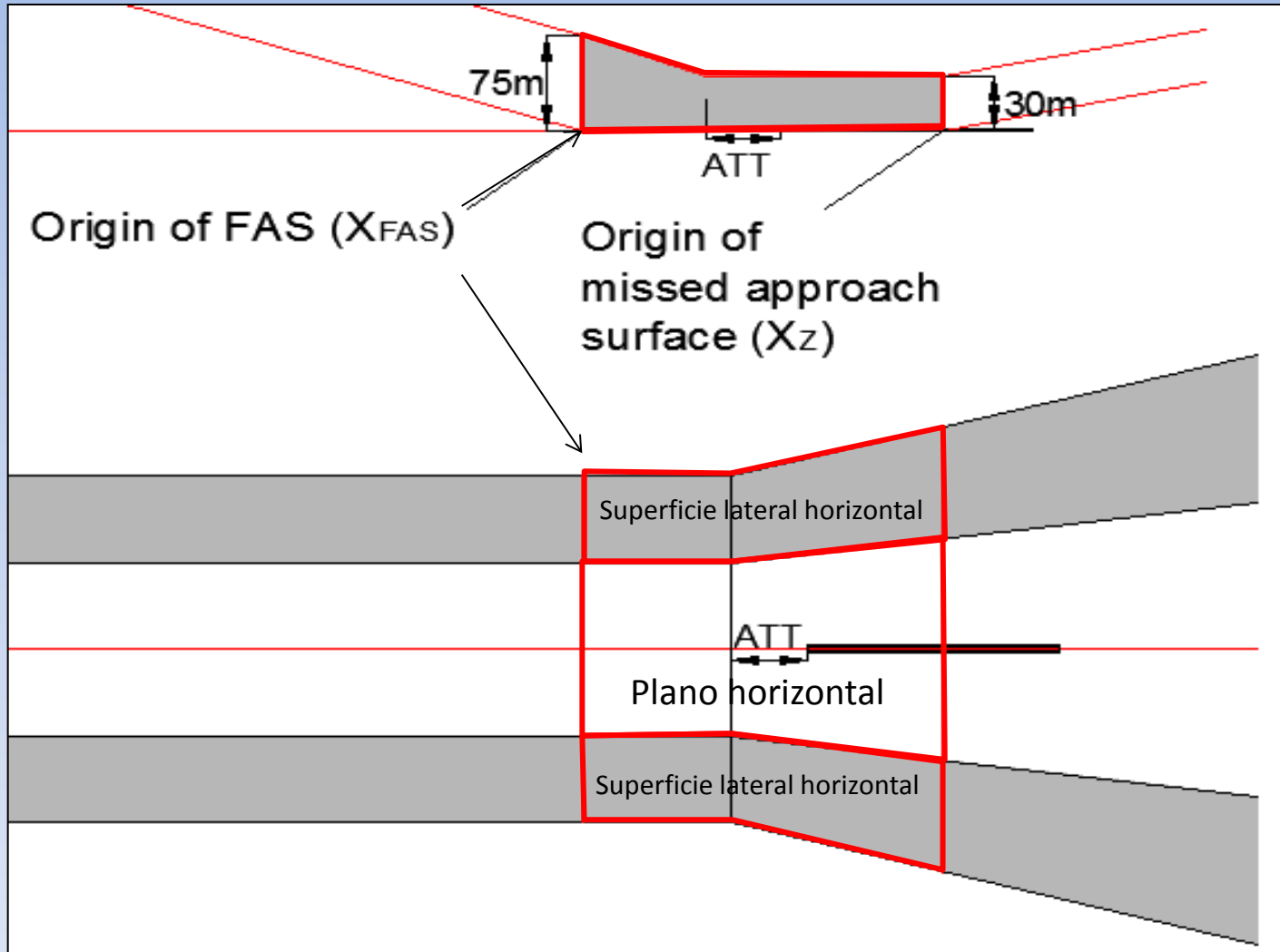


OAS APV

Ground plane: is defined by a surface at threshold level bounded by the LNAV primary area between the origin of the FAS and the origin of the missed approach Z surface (Xz).

- The lower/inner edges of the ground plane side surfaces are defined by the edges of the LNAV primary area at threshold level.
- The upper/outer edges of the side surfaces are defined by the outer edges of the LNAV secondary areas at the height of H_i above threshold at the origin of XFAS and the outer edges of the LNAV area, reducing to 30 m above threshold at ATT before threshold and continuing at 30 m above threshold up to Xz.

Plano Horizontal

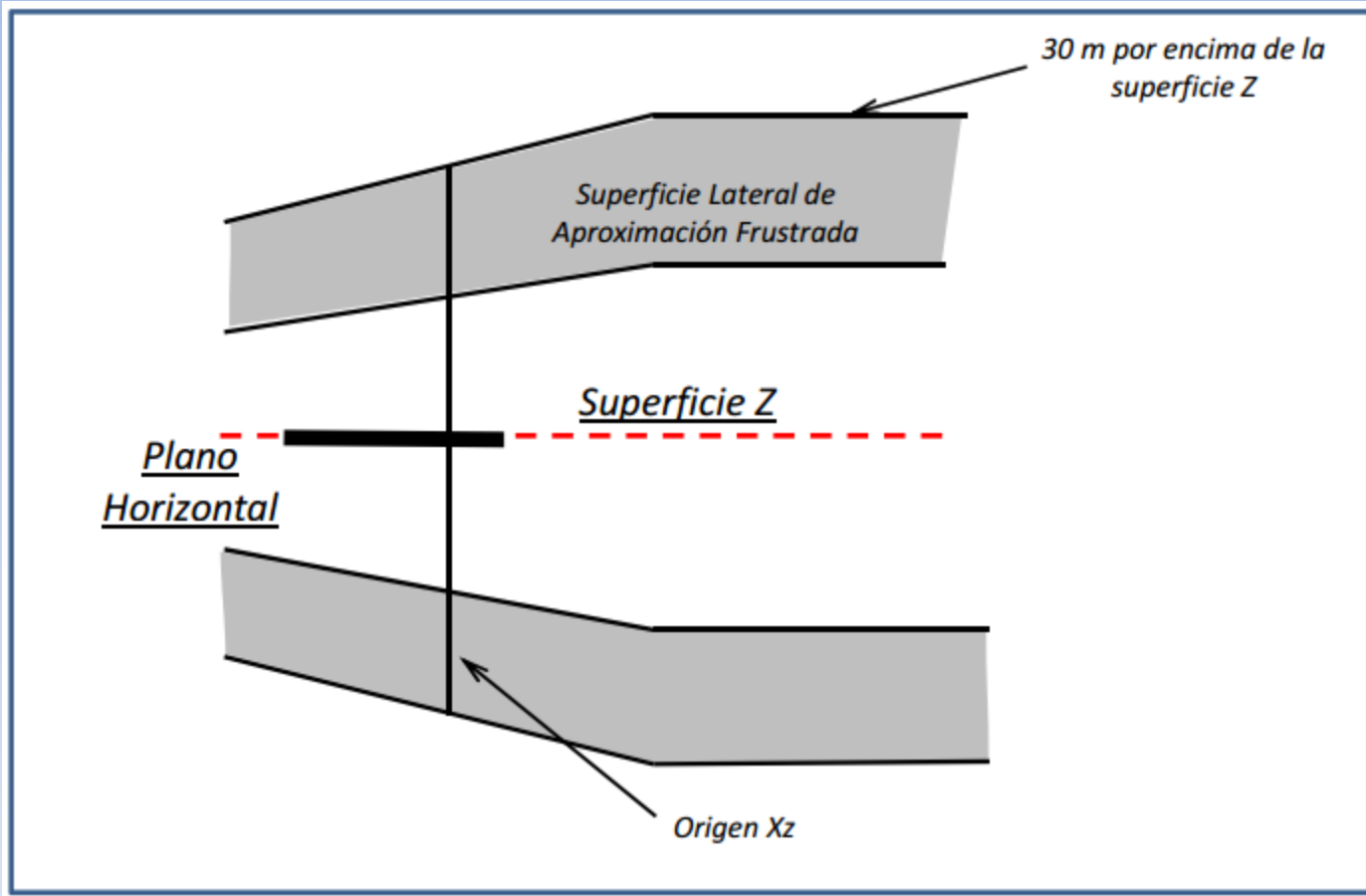


OAS APV

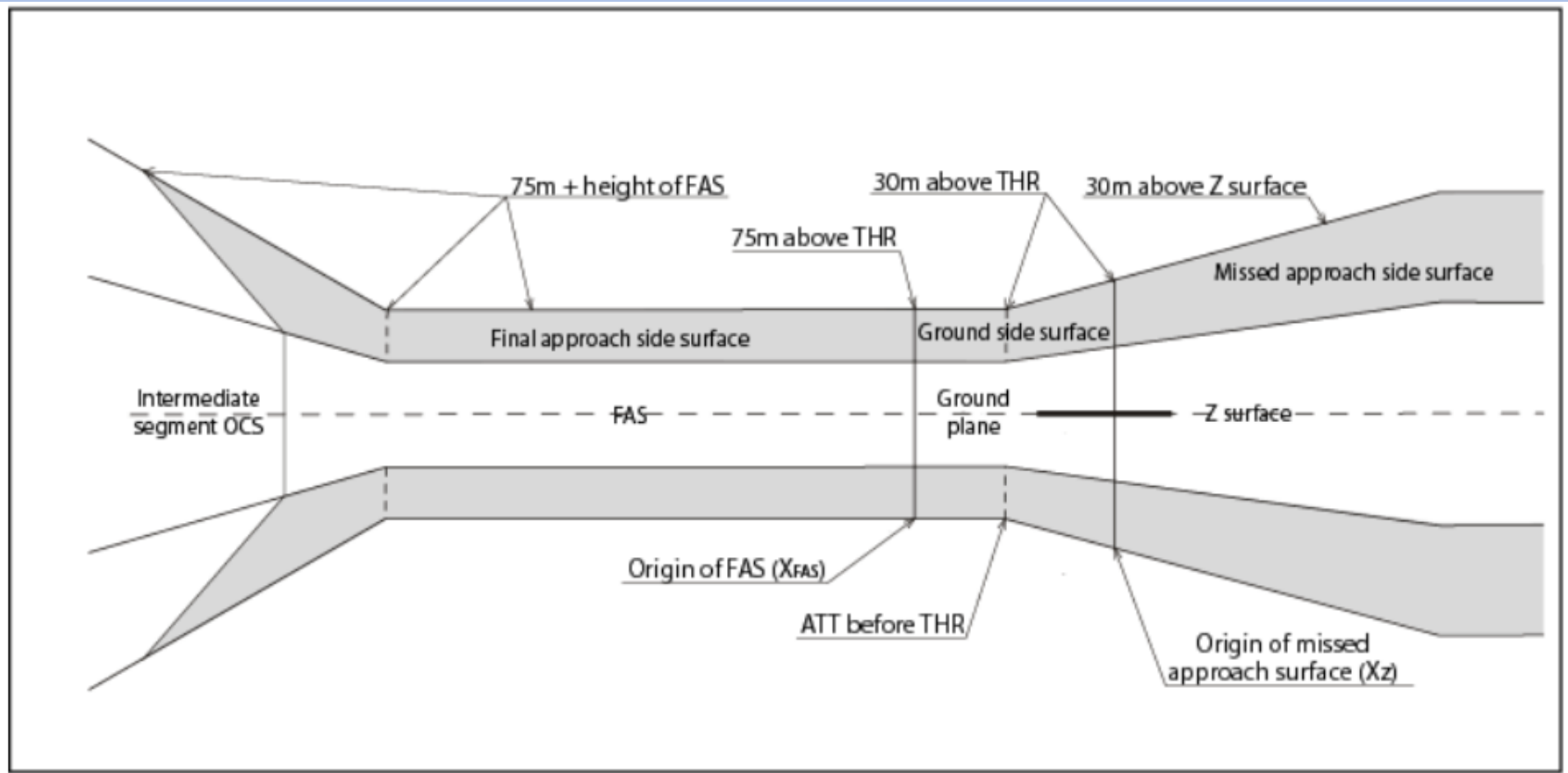
Missed approach (Z) surface: it begins at threshold level between -900 m (CAT A-B), -1100 m (CAT C) and -1400 m (CAT D) relative to threshold. It has a nominal gradient of 2.5 per cent and is bounded laterally by the LNAV primary area.

- The lower/inner edges of the associated side surfaces are defined by the edges of the LNAV missed approach primary area.
- The outer edges of the LNAV secondary areas 30 m above the missed approach (Z) surface.

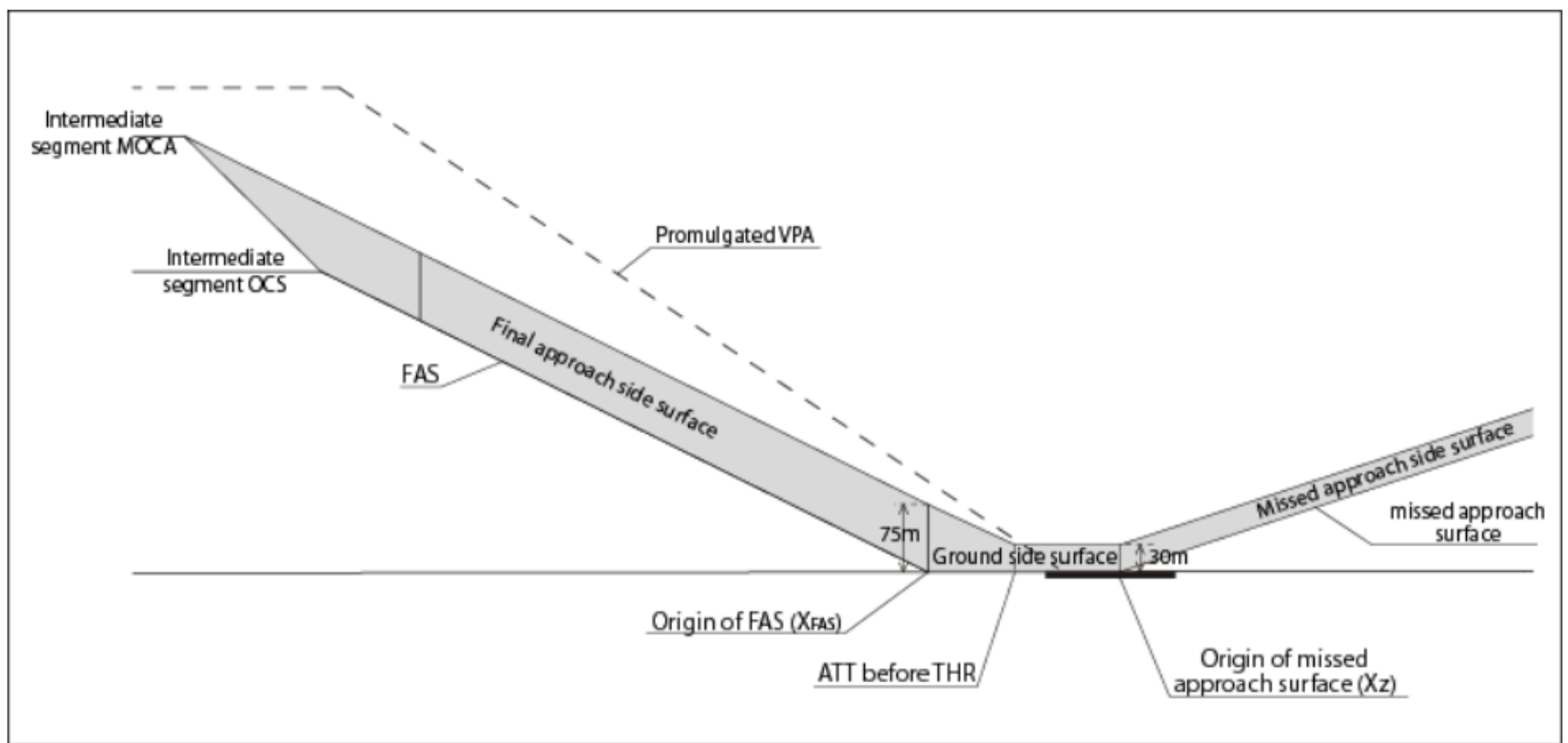
Missed approach (Z) surface



Missed approach (Z) surface plan view



Missed approach (Z) surface profile view

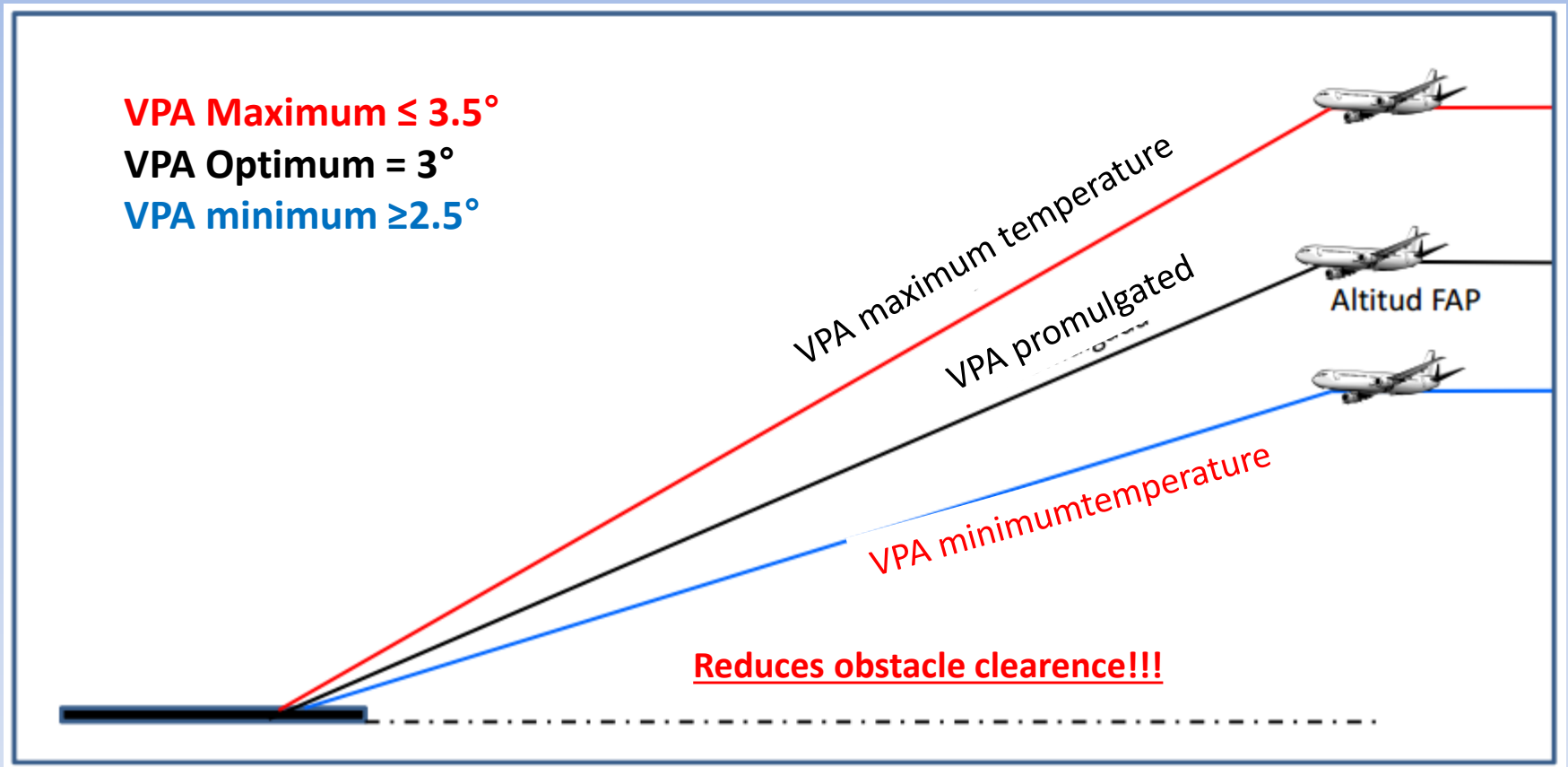


(aerodrome and intermediate segment OCS at or below 5 000 ft)

Temperature correction

- APV Baro VNAV is based on barometric vertical guidance so it is influenced by temperature.
- The procedure shall take into account the effect of temperature on vertical path angle.
- The calculated minimum safe altitudes/heights must be adjusted when the ambient temperature on the surface is much lower than that predicted by the standard atmosphere.
- The minimum VPA for the proposed minimum promulgated temperature shall be calculated. If the minimum VPA is less than 2.5° , the VPA shall be increased to ensure the minimum VPA is equal to or greater than 2.5°

Temperature correction



Temperature correction

Equation to calculate temperature correction:

$$\Delta h = -H * ((15 - (t_0)) / (273.15 + t_0 - 0.5 * L_0 * (H + H_{ss})))$$

Where:

H= Height at FAP.

HSS= Setting source height (often Ad.)

L₀= 0.00198°C/ft (standard temperature lapse rate)

t₀= standard temperature at sea level.

$$t_0 = t_{ad} + L_0 * L_{ad}$$

t_{ad}= aerodrome temperature.

L_{ad}= aerodrome altitude

Procedure Computations

Calculation of minimum VPA:

$$\tan_{\text{MIN/VPA}} = (H - \Delta h - \text{RDH}) / D_{\text{FAP-THR}}$$

Where:

H= Height FAP.

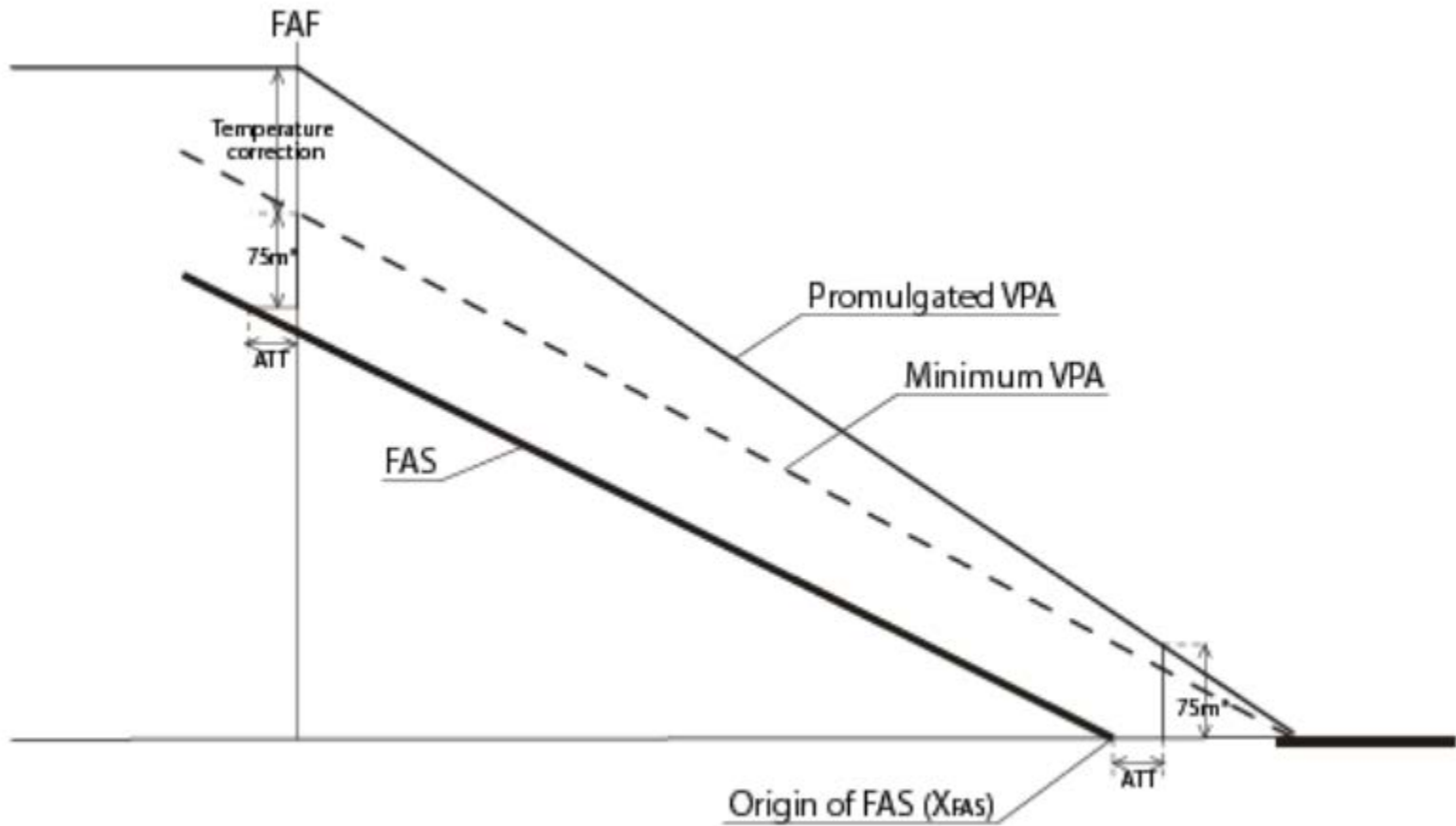
Δh = temperature correction

RDH= Reference datum height.

VPA= promulgated vertical path angle

Note: If minimum VPA is less than 2.5°, the promulgated VPA shall be increased to ensure the minimum VPA is equal to or greater than 2.5°

Minimum VPA TAN



* 75m to be replaced by 105 and 120m to determine FAS' and FAS'' respectively

Procedure Computations

The origin of the FAS at threshold level shall be determined as follows:

$$X_{FAS} = [(H_i - RDH) / \tan VPA] + ATT$$

The angle of the FAS (α_{FAS}) shall be determined as follows:

$$\tan \alpha_{FAS} = (H - \Delta h - H_i) * \tan VPA / (H - H_i)$$

Where:

H=height at FAP

Δh =Temperature correction

H_i =Specified height

RDH=Reference datum height

VPA=Promulgated VPA

ATT=Tolerance at MAPt

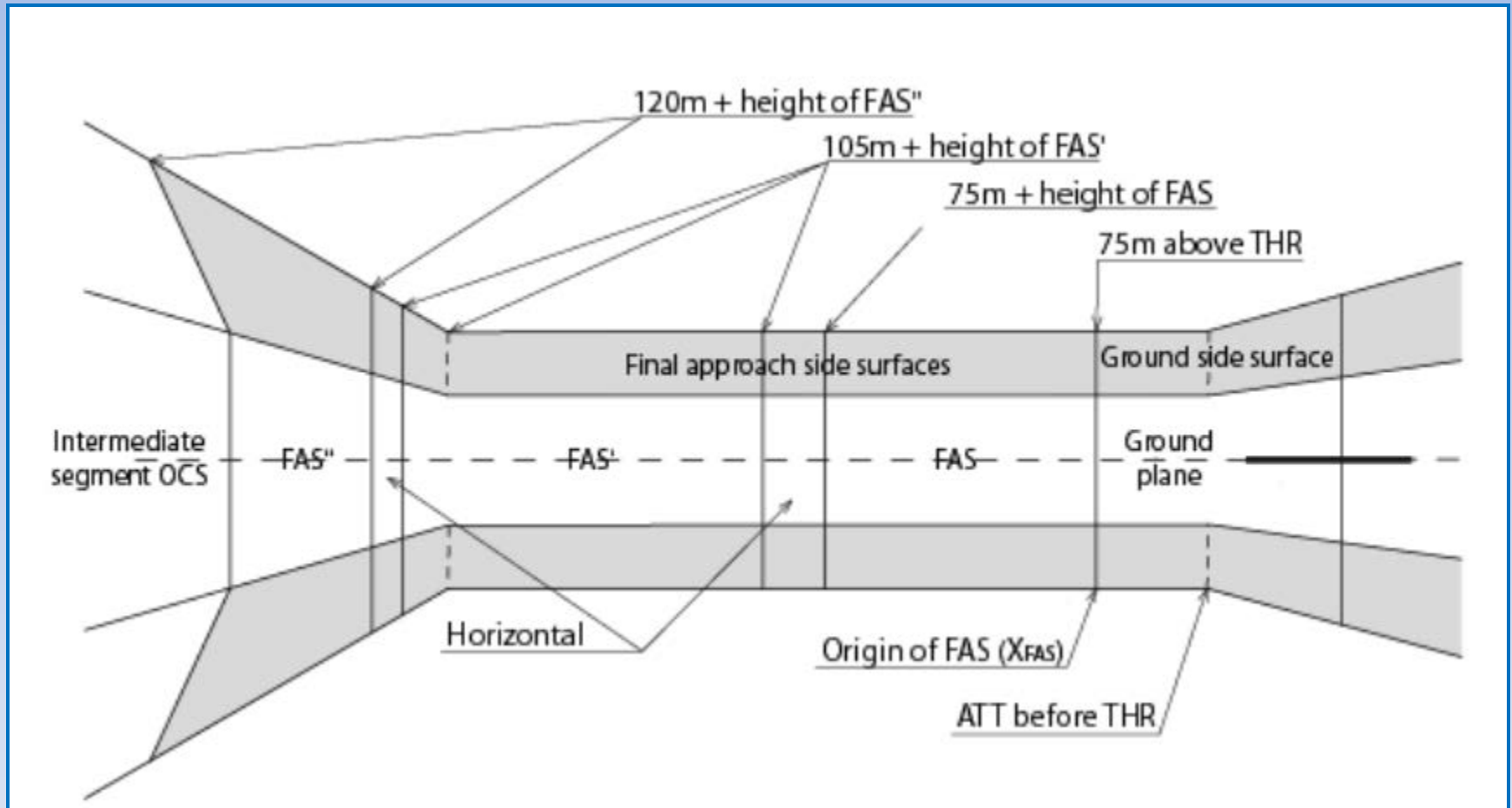
Procedure Computations

FAS height (hFAS) at x distance from THR shall be determined as follows:

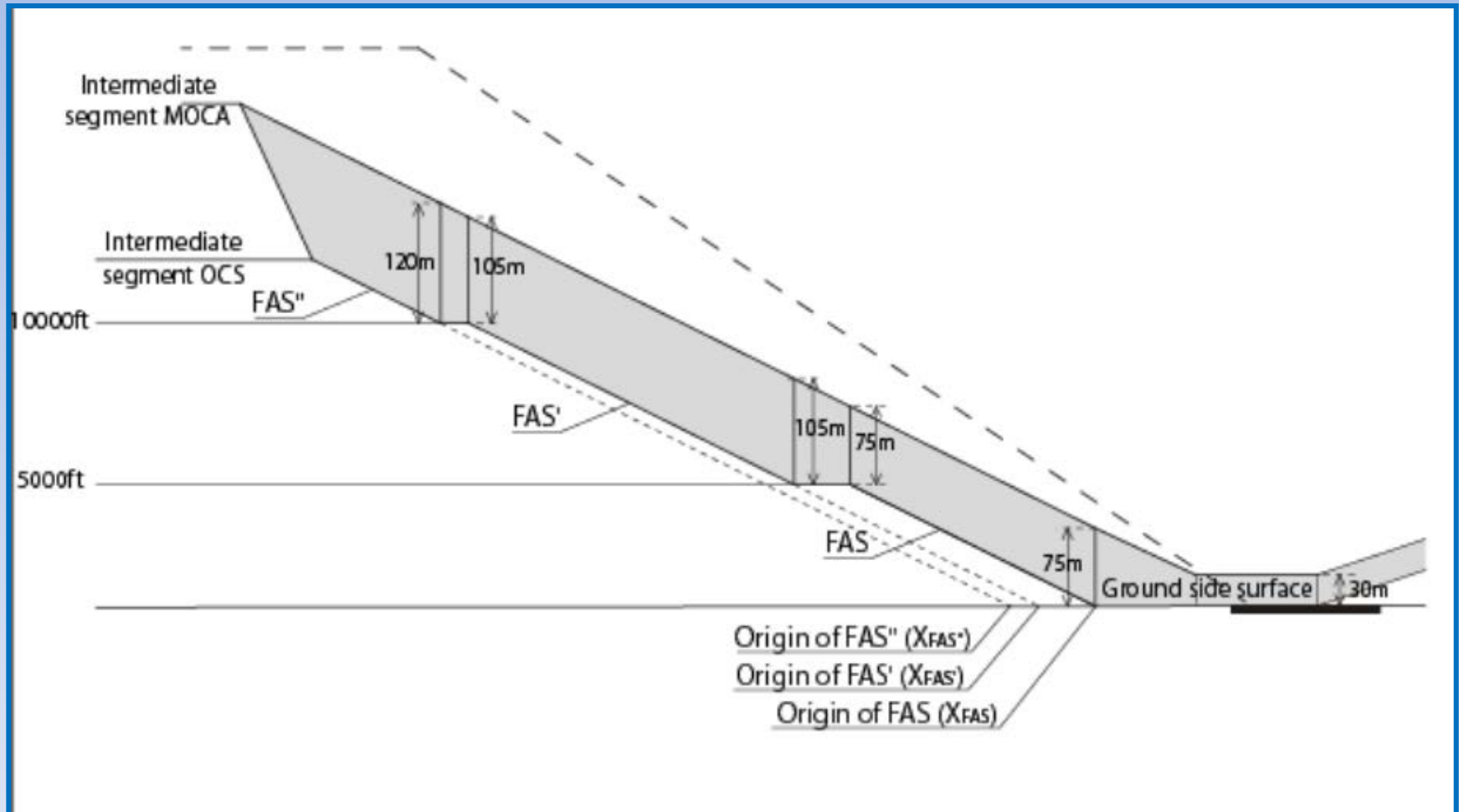
$$hFAS=(X-XFAS)*Tan\alpha FAS$$

Where hFAS results in FAS elevation above 5000 ft, then from that x coordinate onwards, H_0 of 75 m shall be replaced by H_{5000} of 105 m75 mts, In such a case, $\tan\alpha FAS'$, $XFAS'$ and $hFAS'$ shall be recalculated by applying 105 m (H_{5000}). A similar recalculation shall be carried out if the application of 105 m (H_{5000}) results in a FAS'' elevation above 10 000 ft.

Final approach surfaces above 5000 ft



Final approach surfaces above 5000 ft



Determination of OCH APV Segment

Accountable obstacles are divided into approach and missed approach obstacles. The standard method of categorization is as follows:

- a) Approach obstacles are those located between the beginning of the final approach segment and the origin of the Z surface.
- b) Missed approach obstacles are those located in the remainder of the missed approach segment

Determination of OCH

Approach obstacles

For final approach obstacles penetrating the FAS or the ground plane, the final approach OCH shall be determined by adding the category related height loss margin (see 4.5) to the height of the obstacle.

Aircraft category (Vat)	Margin using barometric altimeter	
	Meters	Feet
A – 169 km/h (90 kt)	40	130
B – 223 km/h (120 kt)	43	142
C – 260 km/h (140 kt)	46	150
D – 306 km/h (165 kt)	49	161

Determination of OCH

Approach obstacles

For final approach obstacles penetrating the final approach side surface or the side surface associated with the ground plane, the final approach OCH shall be determined by adding a value, reduced linearly from the full height loss value at the inner edge of the side surface to zero at the outer edge of the side surface, to the height of the obstacle.

$$HL(\text{red}) = 2 * HL * (1 - ABS(Y) / SWt)$$

Where:

HL= Height loss

ABS(Y)= Absolute distance of the obstacle from approach trajectory.

SWt= Total semi area width

Determination of OCH

Obstacles on side surface of ground plane

To assess if an obstacle under the side surface of the ground plane before ATT penetrates this surface, use the following equation:

$$H_{(GND)} = \left[\left\{ \frac{X_{\text{obst}} - \text{ATT}}{X_{\text{FAS}} - \text{ATT}} * 45 \right\} + 30 \right] * (\text{ABS}(Y_{\text{obst}}) - Sw/Sw)$$

Where:

X_{obst}= Obstacle X Coordinate.

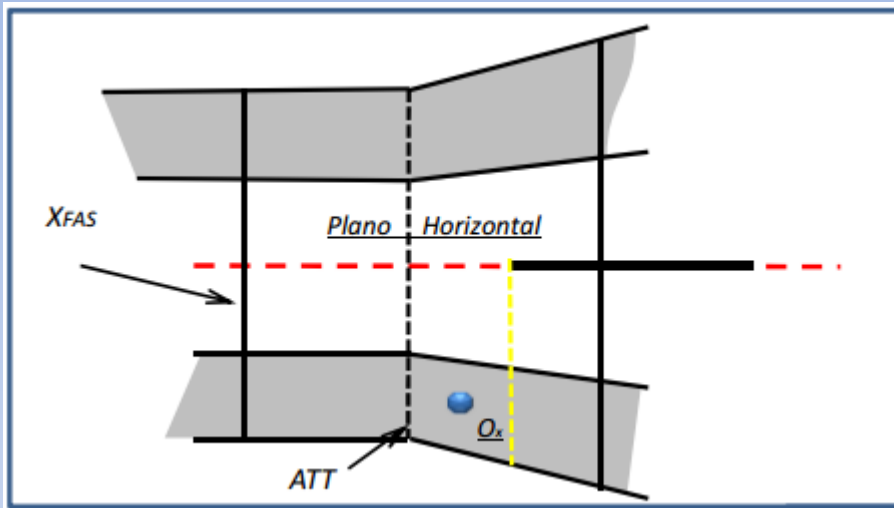
X_{FAS}= Origin of FAS coordinate.

ATT= Map tolerance.

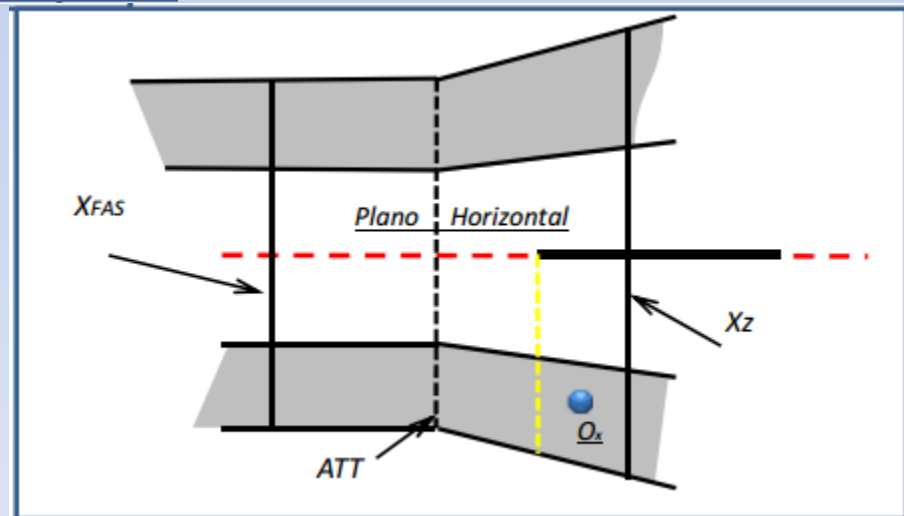
Y_{obst}= Obstacle Y coordinate.

Sw= Secondary area width.

Determination of OCH



**Obstacles after
ATT**



Determination of OCH

Obstacles on side surface of ground plane

To assess if an obstacle under the side surface of the ground plane after ATT penetrates this surface, use the following equation:

$$H(\text{GND}) = 30 * (\text{ABS}(Y_{\text{obst}}) - S_w) / S_w$$

Where:

X_{obst} = Obstacle X coordinate.

XZ = Origin of missed approach surface.

ATT = Missed approach tolerance.

Y_{obst} = Obstacle Y coordinate.

S_w = Secondary area width = $\{(ATT - X_{\text{obst}}) * \tan 15^\circ\} + S_{wt} / 2$

S_wt = Secondary area width at ATT.

Note: If S_w > 3704 m (2NM), use 3704 m (2NM)

Determination of OCH

Height of missed approach surface at range X is:

$$h_{xz} = -(X(\text{Obst}) - X_z) * \tan Z$$

Where:

$X(\text{Obst})$ = Coordinate X of obstacle.

$\tan Z$ = missed approach gradient.

X_z = Origin of missed approach surface.

Determination of OCH

Missed approach obstacles

For missed approach obstacles penetrating a final approach surface, the ground plane or the Z surface, the height of equivalent approach obstacle shall be calculated using the following formula:

$$H_a = \frac{h_{hma} * \text{Cot}Z + (X - X_z)}{\text{Cot}Z + \text{Cot}\emptyset}$$

Where:

h_{hma} = height of the missed approach obstacle.

$\text{Cot}Z$ = cotangent of the Z surface angle.

$\text{Cot}\emptyset$ = cotangent of the VPA

X_z = X coordinate of the missed approach surface (Z).

X = obstacle distance from threshold (positive before, negative after)

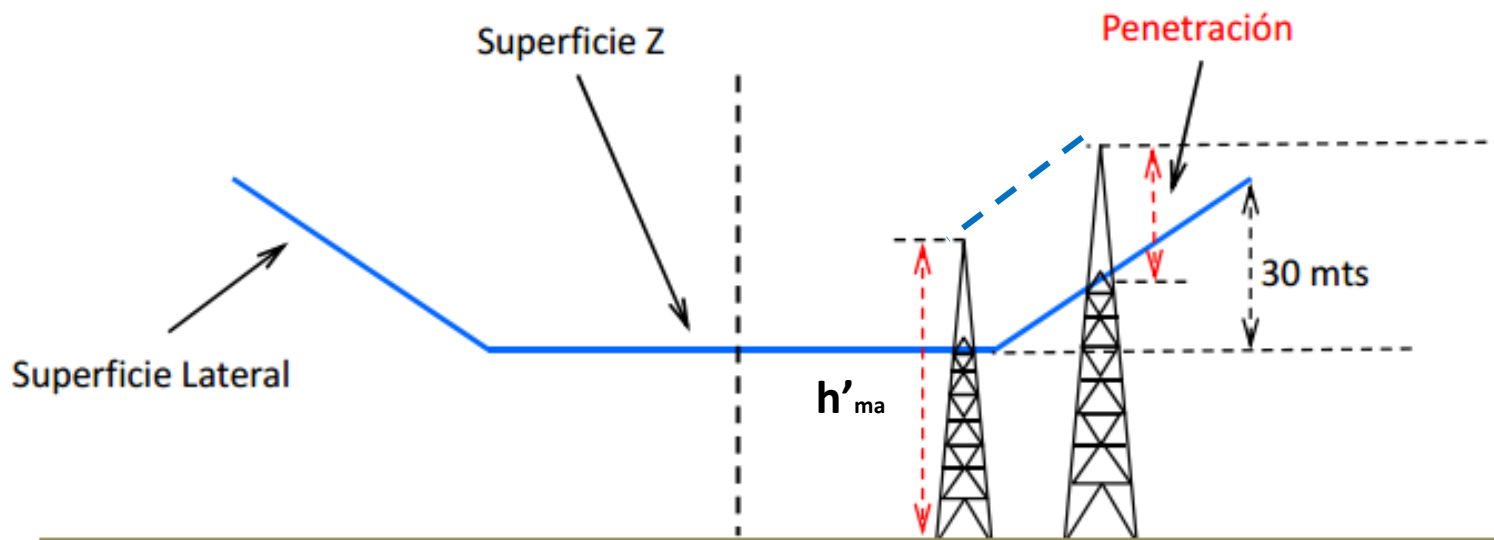
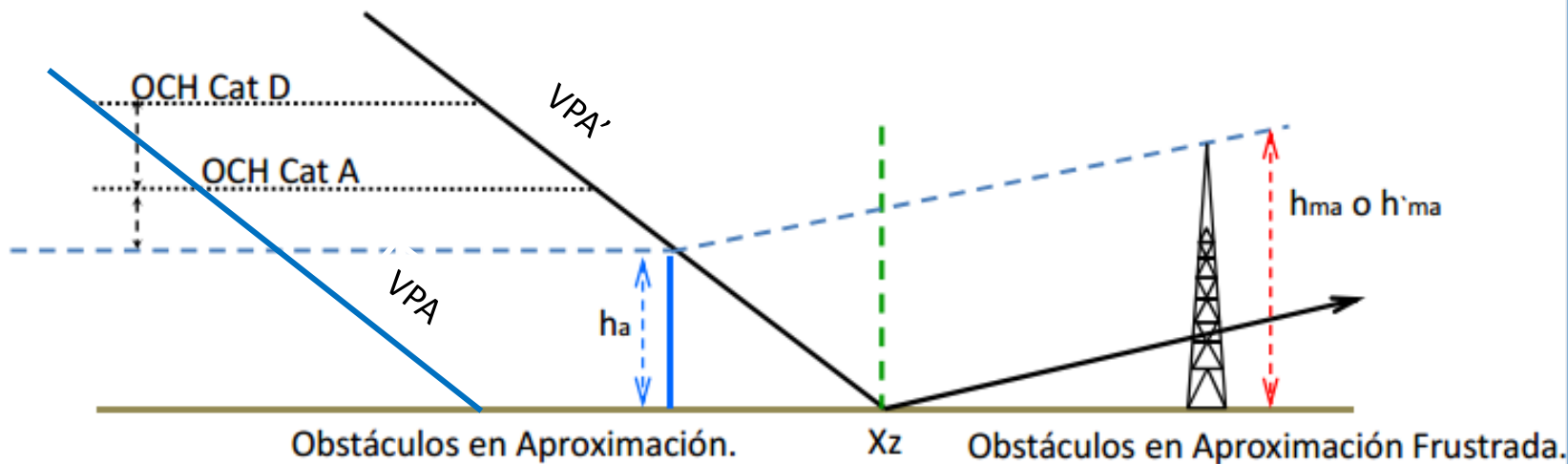
Determination of OCH

For missed approach obstacles penetrating a side surface the height of equivalent approach obstacle shall be calculated using the following formula:

$$h_a = \frac{h'_{ma} * \text{Cot}Z + (x - x_z)}{\text{Cot}Z + \text{Cot}\phi}$$

Where:

where h'_{ma} is the amount of the penetration plus the height of the inner edge of the side surface at the along-track distance of the penetrating obstacle



Determination of OCH

Missed approach Obstacles on side of surface.

To assess if missed approach obstacles penetrate the side surface, use the following formula:

$$H(zsec) = 30 * (ABS(Y_{obst}) - S_w / S_w) + H_{supz}$$

Where:

X_{obst} = Obstacle X coordinate.

X_Z = X coordinate of the missed approach surface (Z).

Y_{obst} = Obstacle Y coordinate.

S_w = Sec. Area width = $\{(ATT - X_{obst}) * \tan 15^\circ\} + S_{wt} / 2$

$H_{supZ} = (X_Z - X_{obs}) * \tan Z$

S_{wt} = Semia area width at ATT.