# PANS-OPS Flight Procedure Design Training for CAAs

**23 August – 03 September 2021**

# 13 – Precision approach

## (Doc. 8168, Vol. 2, Part II, Section 1, Chap. 1)

# Outlines



1. Introduction
2. The precision segment
3. Obstacle assessment in the precision segment
4. P.A. initial and intermediate approach segments
5. P.A. missed approach
6. Publication

# Introduction



- Precision approach procedure:
  - Instrument approach procedure using precision lateral and vertical guidance with minima as determined by the category of operation;
  - Encompass a “Precision segment”.
- Guidance systems or Navaids: ILS, MLS, PAR, GBAS & SBAS.
- General criteria: Arrival, initial and final missed approach segments.
- Specific criteria: intermediate, final segment and initial/intermediate missed approach segments.
- Three method for OCH computation (ILS Cat. II & III):
  - Basic ILS surfaces;
  - Obstacle Assessment Surfaces (OAS);
  - Collision Risk Model.
- No MOC but Height Loss (HL).

# Introduction



- Guidance information:
  - ILS, MLS, PAR, GBAS & SBAS.
- Guidance provided in final segment:
  - Vertically (slope);
  - Laterally .
- In missed approach :
  - No vertical guidance provided;
  - No track guidance required:
    - Dead reckoning track for ILS approach.
- Focus on ILS.

# ILS classification (Ground Navaids)

- First digit:
  - ☞I, II and III : ILS performance.
- Second digit:
  - ☞A, B, C, D, E or T.
    - Point along the RWY axis until which the LOC signal is consistent;
    - Letter T indicates RWY THR.
- Third digit:
  - ☞1, 2, 3 or 4
    - Level of integrity and continuity of service.
- E.g: Cat. III. E.4

# ILS standard conditions : Maximum aircraft dimensions

| Aircraft category | Wingspan (m) | Vertical distance (t) between the flight paths of the wheels and the GP antenna (m) |
|---|---|---|
| H | 30 | 3 |
| A,B | 60 | 6 |
| C, D | 65 | 7 |
| $D_L$ | 80 | 8 |

# ILS standard conditions

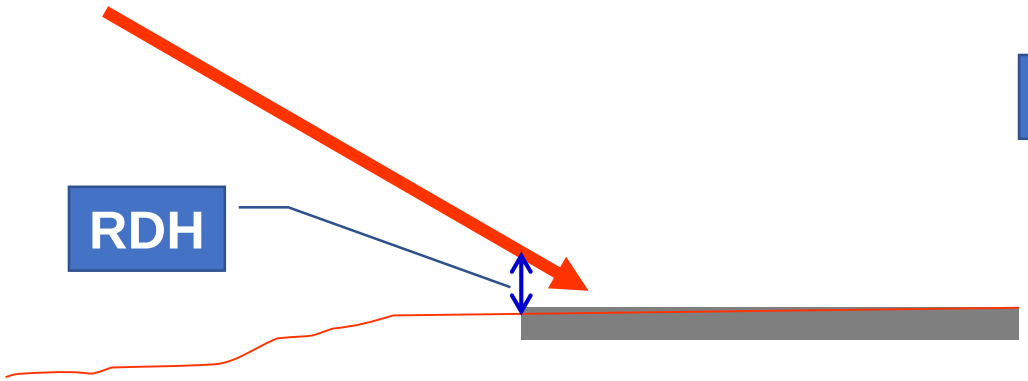
- Maximum aircraft dimensions: Table above;
- Cat. II flown with Flight Director;
- Missed approach gradient : 2.5%;
- ILS sector width : 210 m at landing threshold;
- Glide path angle :
  - Minimum : 2.5°
  - Optimum : 3.0°
  - Maximum : 3.5° (3.0° for Cat. II & III
  - ILS Reference Datum height : 15 m (50 ft);
  - All obstacle referenced to the threshold elevation.
- For Cat. II & III: no penetration of the Annex 14 inner approach, inner transitional and balked landing surfaces.

## ILS basic elements

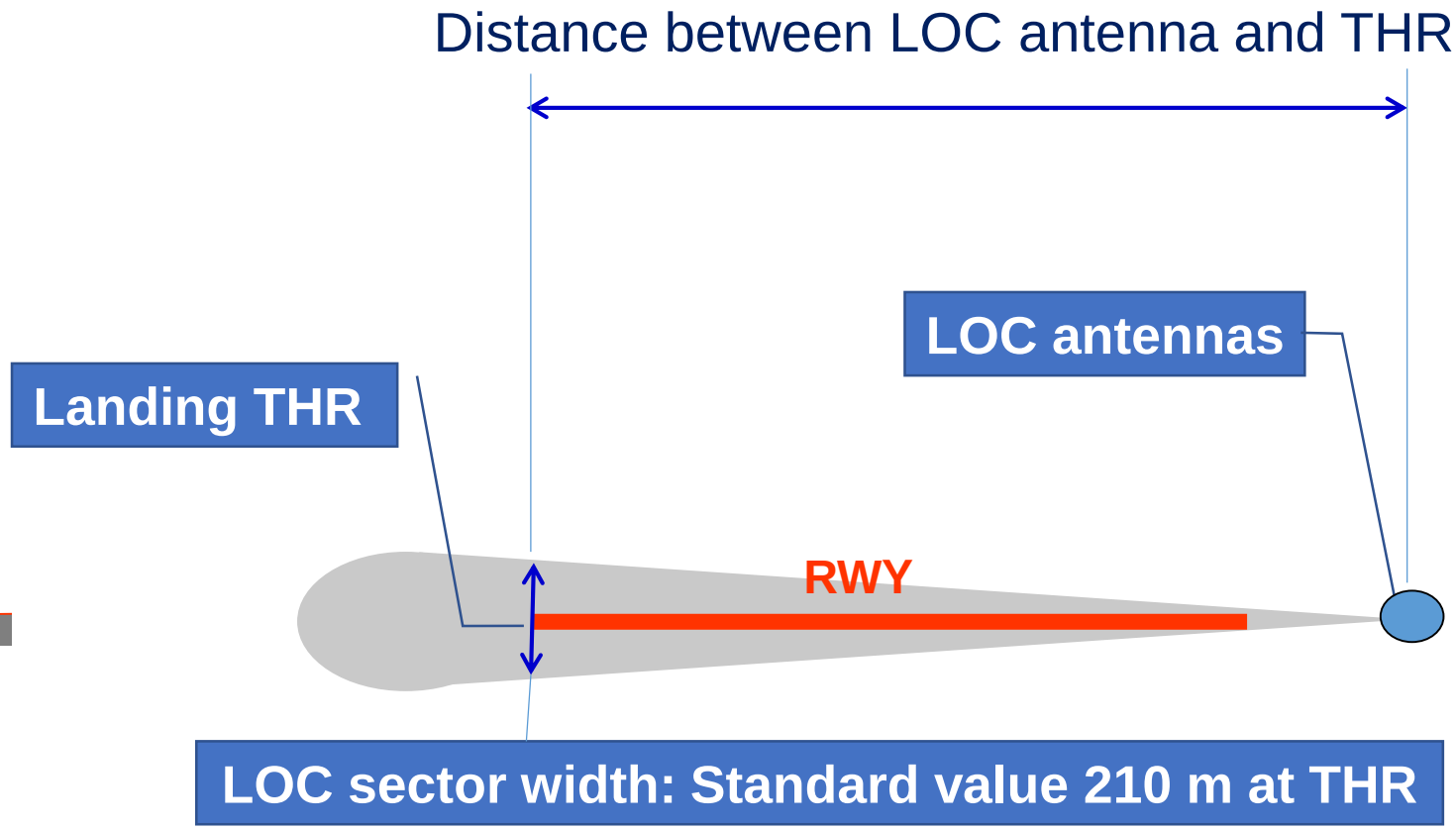
- ILS category of operation;
- ILS geometry:
  - LOC sector width at THR;
  - Glide path elevation angle;
  - Reference Datum Height (RDH);
  - Distance between LOC antenna and landing THR (measured).

# RDH : Reference Datum Height

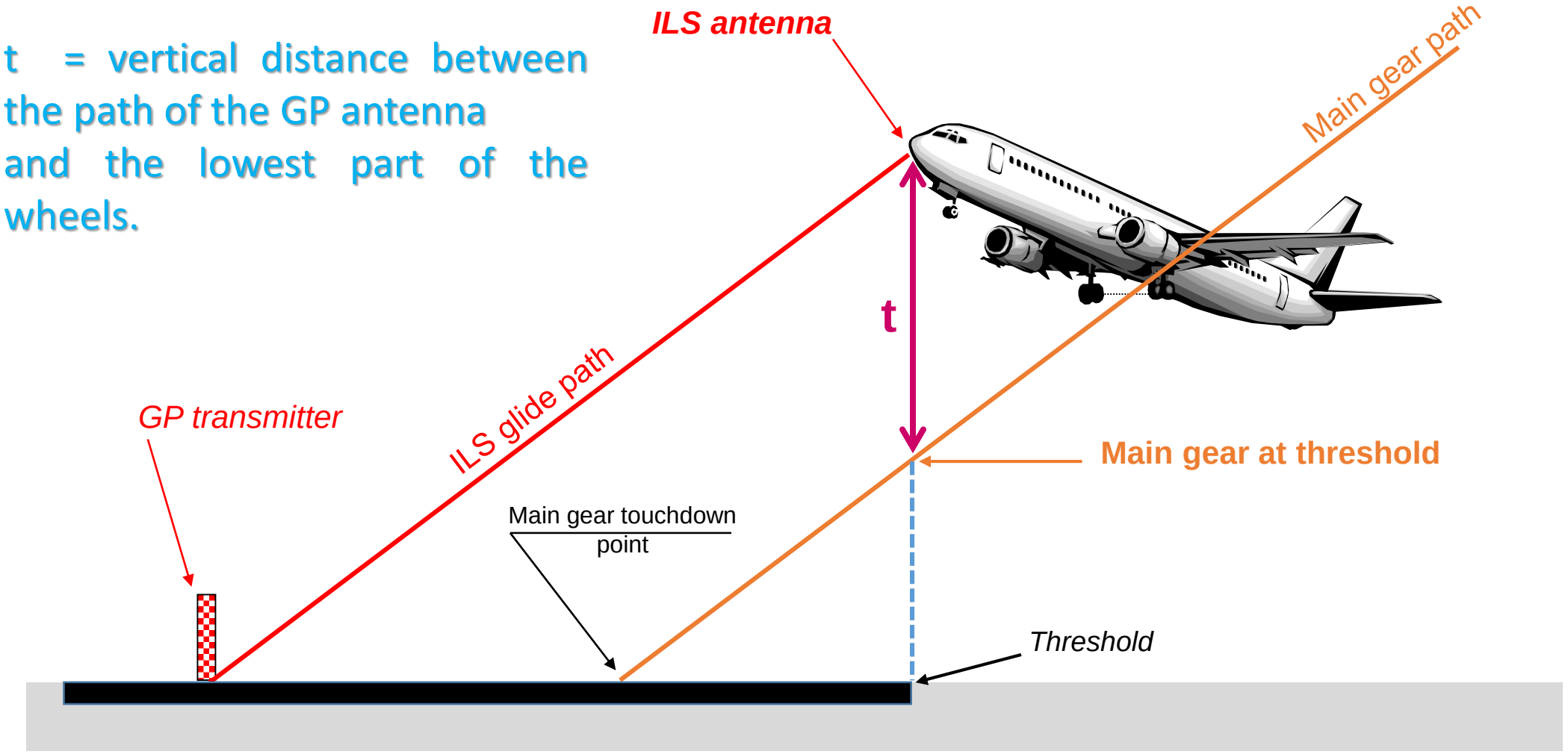
- RDH:
  - ☞Height of GP plan over the threshold:
    - Optimum : 15 m;
    - Cat. I tolerance : ± 3 m;
    - Cat. II & III : + 3 m.




# LOC parameters



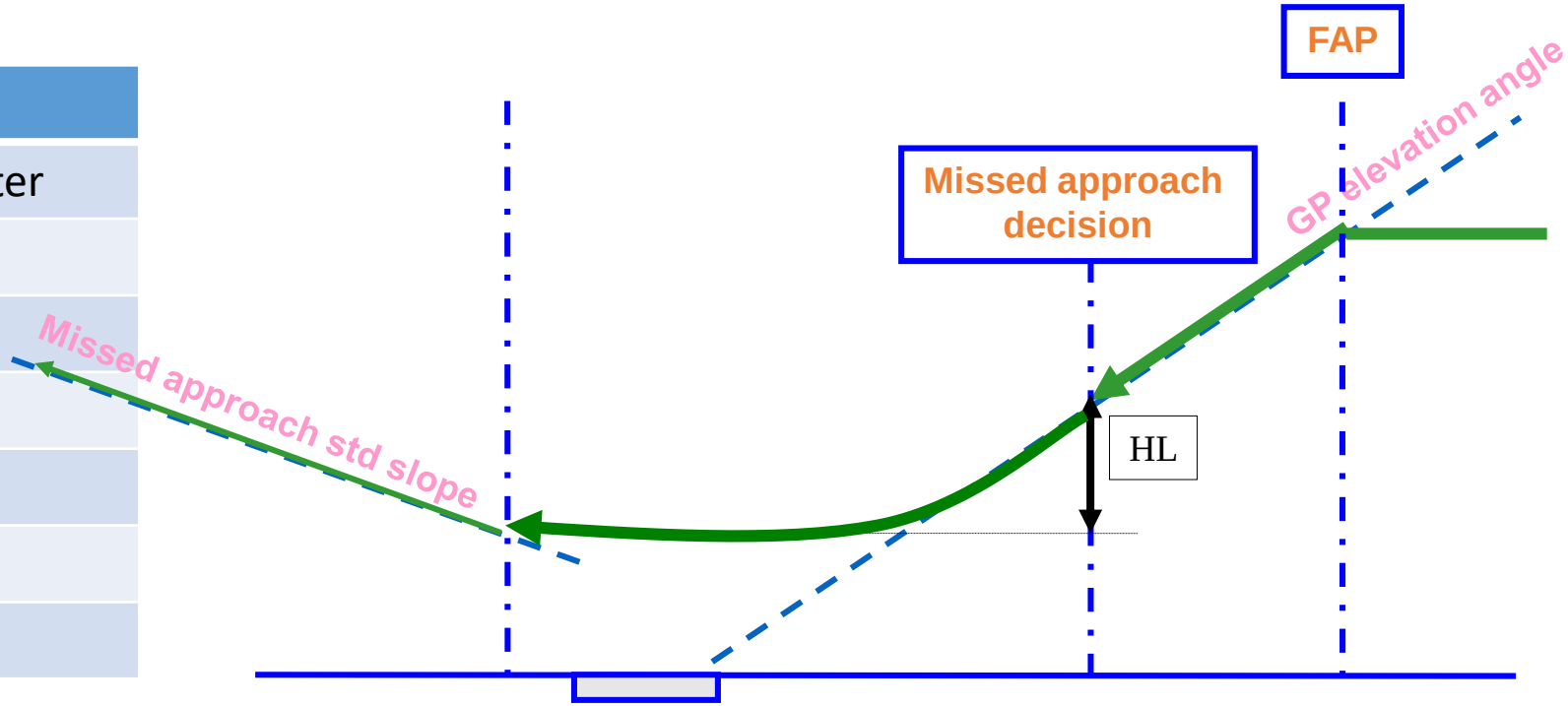
t = vertical distance between the path of the GP antenna and the lowest part of the wheels.



# Understanding Height Loss

HL: maximum amount of height lost by aircraft performing the transition between final and standard climbing slope.

| A/C Cat. | Height Loss Values | | | |
|---|---|---|---|---|
| | Pressure altimeter | | Radio altimeter | |
| | M | Ft | M | ft |
| A | 40 | 130 | 13 | 42 |
| B | 43 | 12 | 18 | 59 |
| C | 46 | 150 | 22 | 71 |
| D | 49 | 161 | 26 | 85 |
| H | 35 | 115 | 8 | 25 |



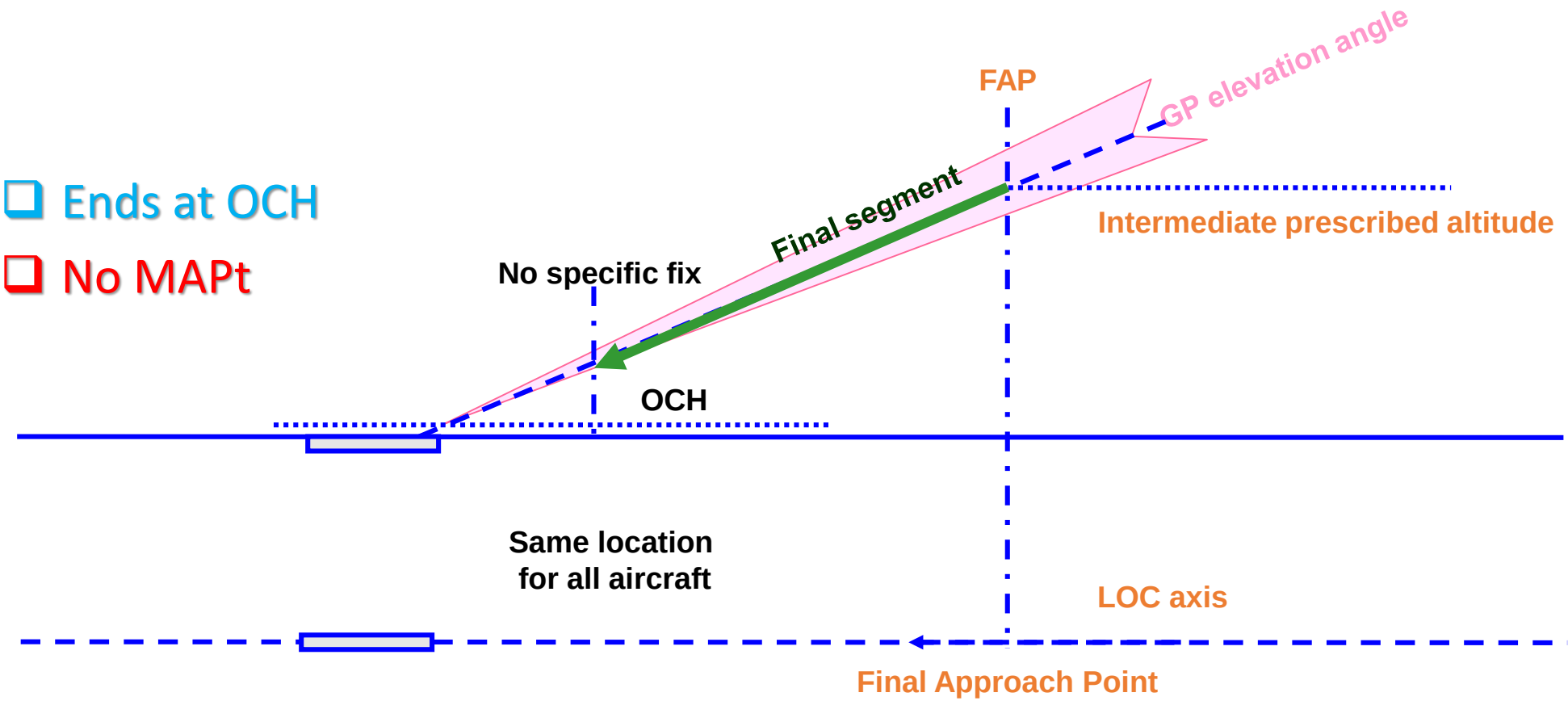
# Introduction

- HL adjustment: HL must be adjusted in certain cases:
  - Airfield elevation > 900 m (2 953 ft):
    - HL value increased by 2% of the radio altimeter margin per 300 m (984 ft) airfield elevation.
  - Glide path steep angle (> 3.2°):
    - HL value increased by 5% of the radio altimeter margin per 0.1° increase in GP (between 3.2° and 3.5°);
- Effect of temperature (T) on pressure altitudes:
  - Pressure altitude decreases with T.
  - Very important in APV baro-VNAV.

# The precision segment

# Final approach segment

- Ends at OCH
- No MAPt



# Final approach segment



- Contains a fix or facility to check :
  - Glide path elevation angle;
  - Altimeter information;
  - This check can be done at FAP.
- Outer marker or equivalent DME distance (tenth of NM);
- Fix tolerances on final segment:
  - Marker
    - Tolerance area : +/- 0.5NM.
  - DME distances:
    - in 1/10 of NM;
    - Tolerance area to be computed.

# Obstacle survey in precision approach



- Accurate DTM or charts at appropriate scales :
  - 1/25 000 or 1/50 000;
  - Contour lines;
  - Isolated obstacles.
- Allowance for vegetation;
- Man-made obstacles (up-to-date);
- Obstacles depicted on aerodrome charts (IFR or VFR).

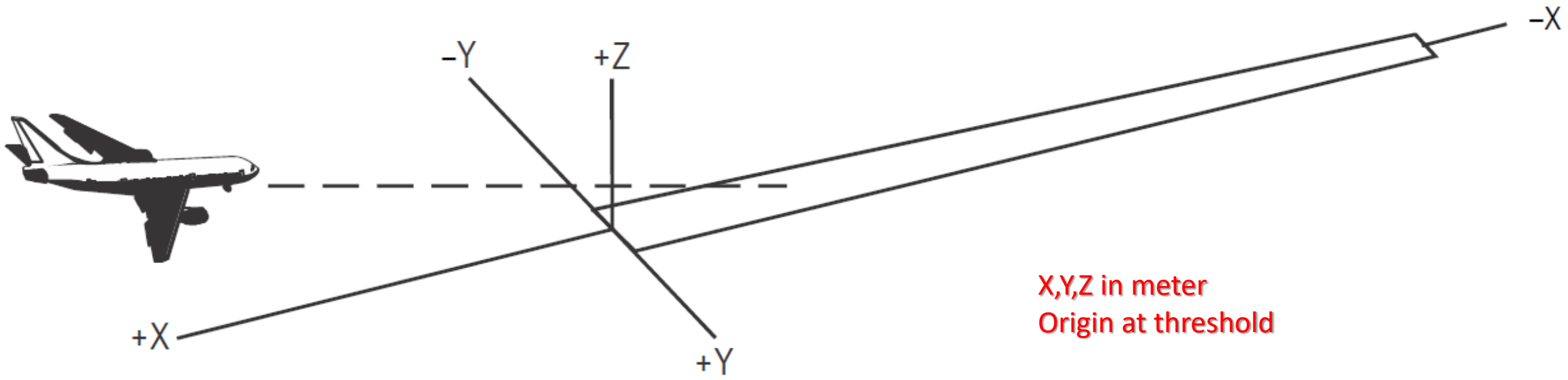
# Precision segment

- Origin: FAP;
- Termination (Whichever is lower):
  - Start of Final Missed approach or,
  - When missed approach surface reaches 300 m (984 ft) above threshold elevation.

# Obstacle assessment in the precision segment

# Coordinates system






X,Y,Z in meter
Origin at threshold

**Figure II-1-1-13. System of coordinates**

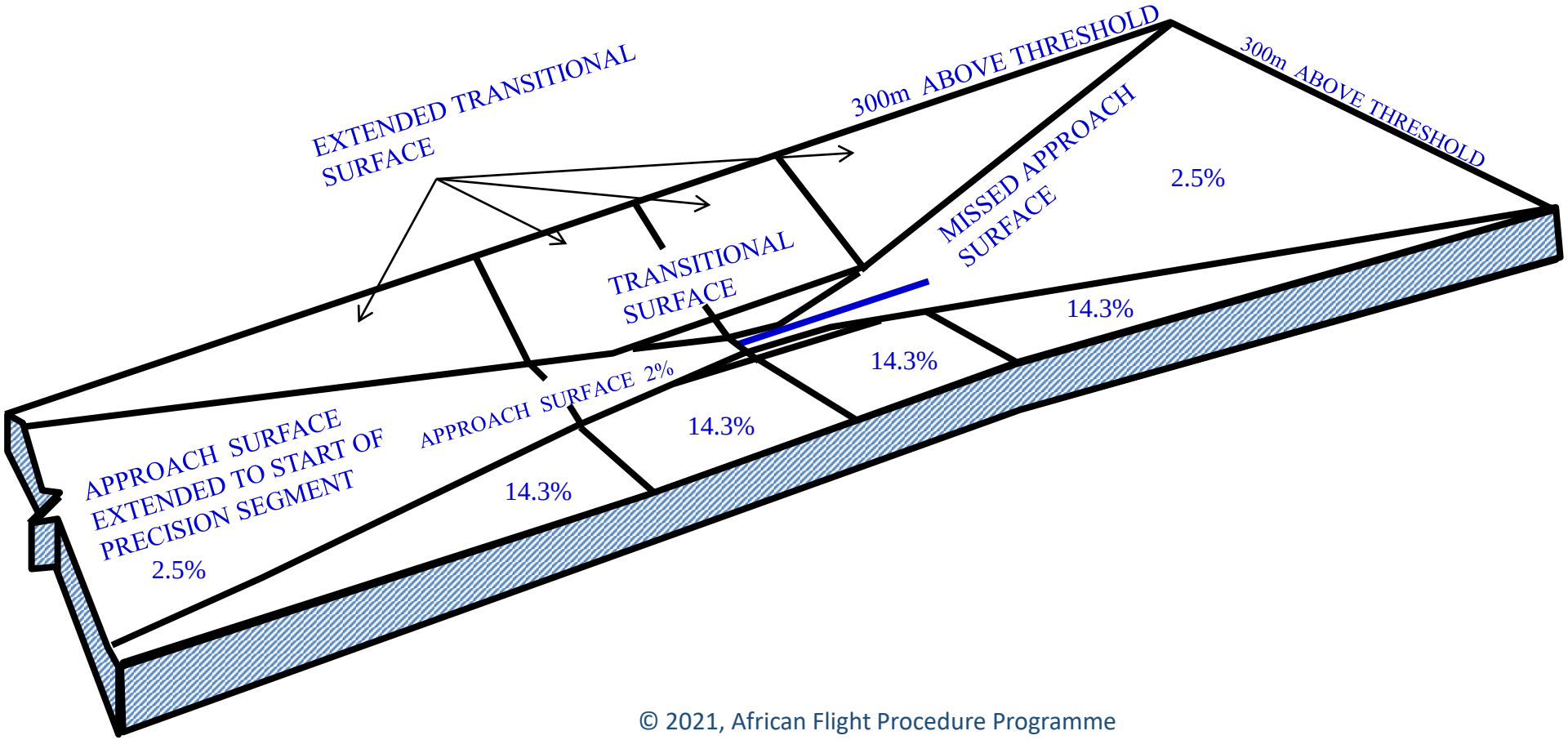
# OCHps computation



- Based on statistical record of ILS approach;
- No more MOC BUT a maximum risk of collision between A/C and obstacles:
  - Overall safety target of $10^{-7}$ (risk of collision with obstacles);
  - Fits with obstacle clearance for final and initial/intermediate M.A.
- Height loss/altimeter margin (HL) in case of missed approach:
  - OCH provided per aircraft category.
- Three methods for OCH computation:
  - Basic ILS surfaces (derived from Annex 14 surfaces);
  - Obstacle Assessment Surfaces (OAS);
  - Collision Risk Model (CRM), a computer program.

# OCHps computation

## Basic ILS surfaces template



# OCHps computation

## Basic ILS surfaces obstacle assessment

- Obstacle selection:
  - ☞All obstacles which penetrate the Basic ILS surfaces are accounted;
  - ☞Some obstacles might be exempted in specific cases (Table II-1-1-3):
    - GP antenna;
    - A/C taxiing or in holding bays.
- OCHps calculation:

**O.C.H.ps =Highest penetrating obstacle + Height Loss**

## Basic ILS surfaces obstacle assessment issues

- Inconveniences:
  - Many plane surfaces not adapted to ILS;
  - A lot of obstacles to process;
  - Pessimistic value for the OCA/H.
- Required for:
  - Cat II and cat III operations (no obstacles penetrating “inner surfaces”).

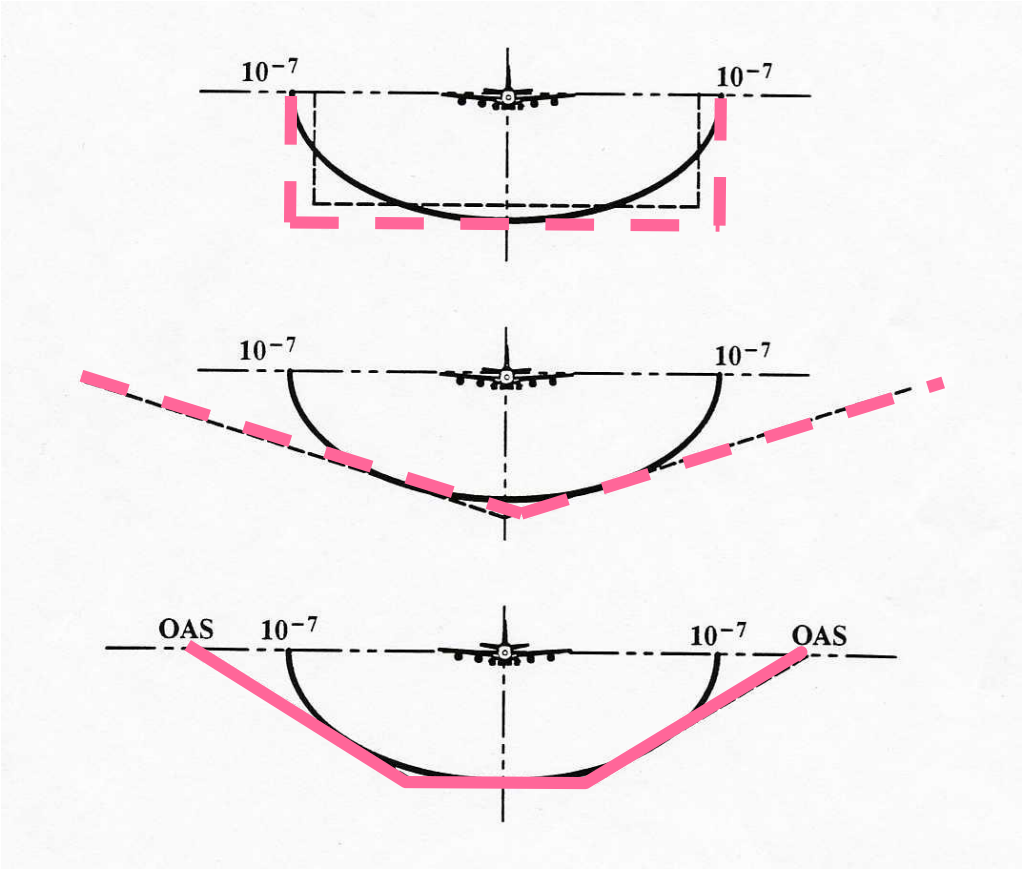
# OCHps computation

## OAS and CRM methods

- Best methods for OCH computation:
  - Based on statistical data (survey of ILS app);
  - adapted to ILS and A/C.
- Advantages :
  - Handle easily a lot of obstacles:
    - Computer assistance available.
  - Accuracy : lowest value of OCH with CRM method.

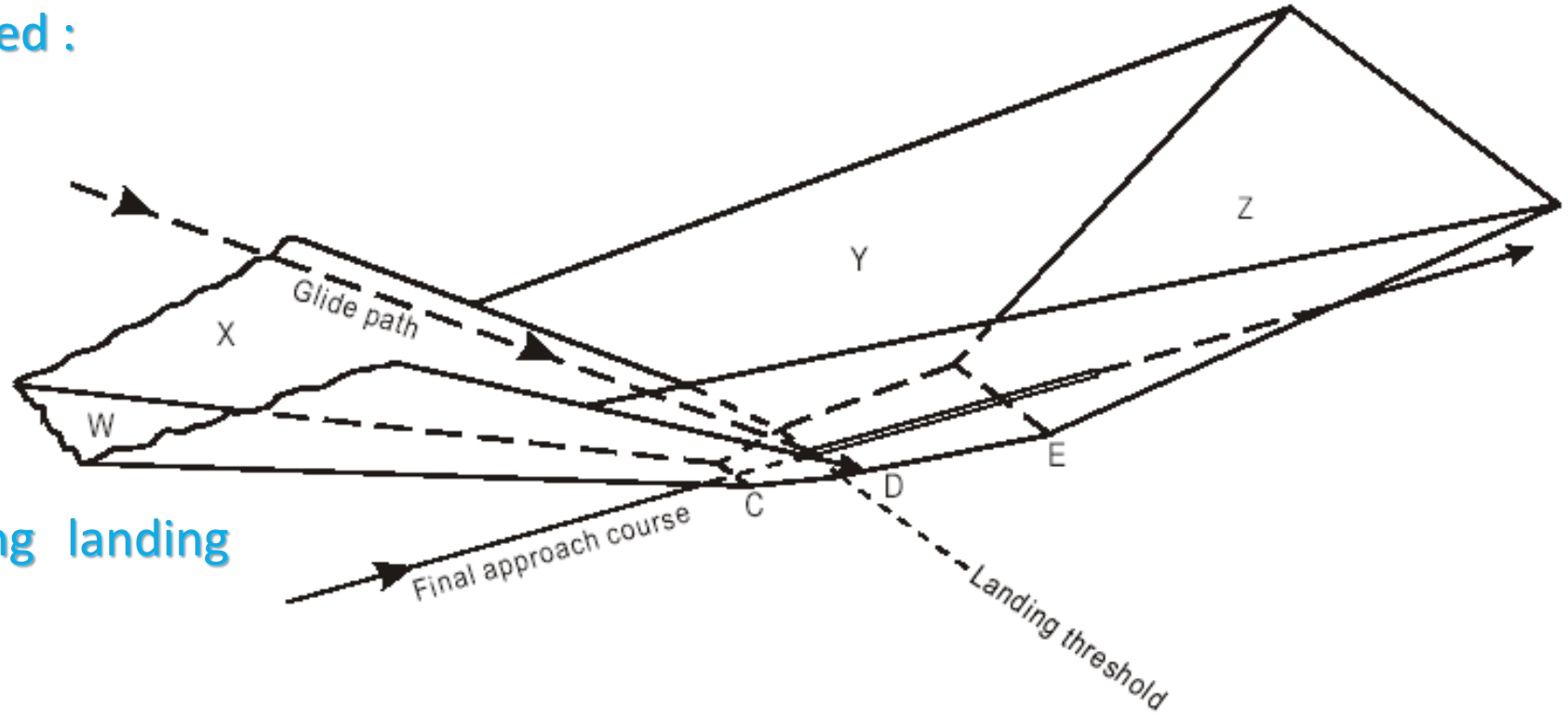
## OAS: From statistics to template

- The **probability** to find an aircraft (in the precision segment) outside this volume is **less than $10^{-7}$ .**



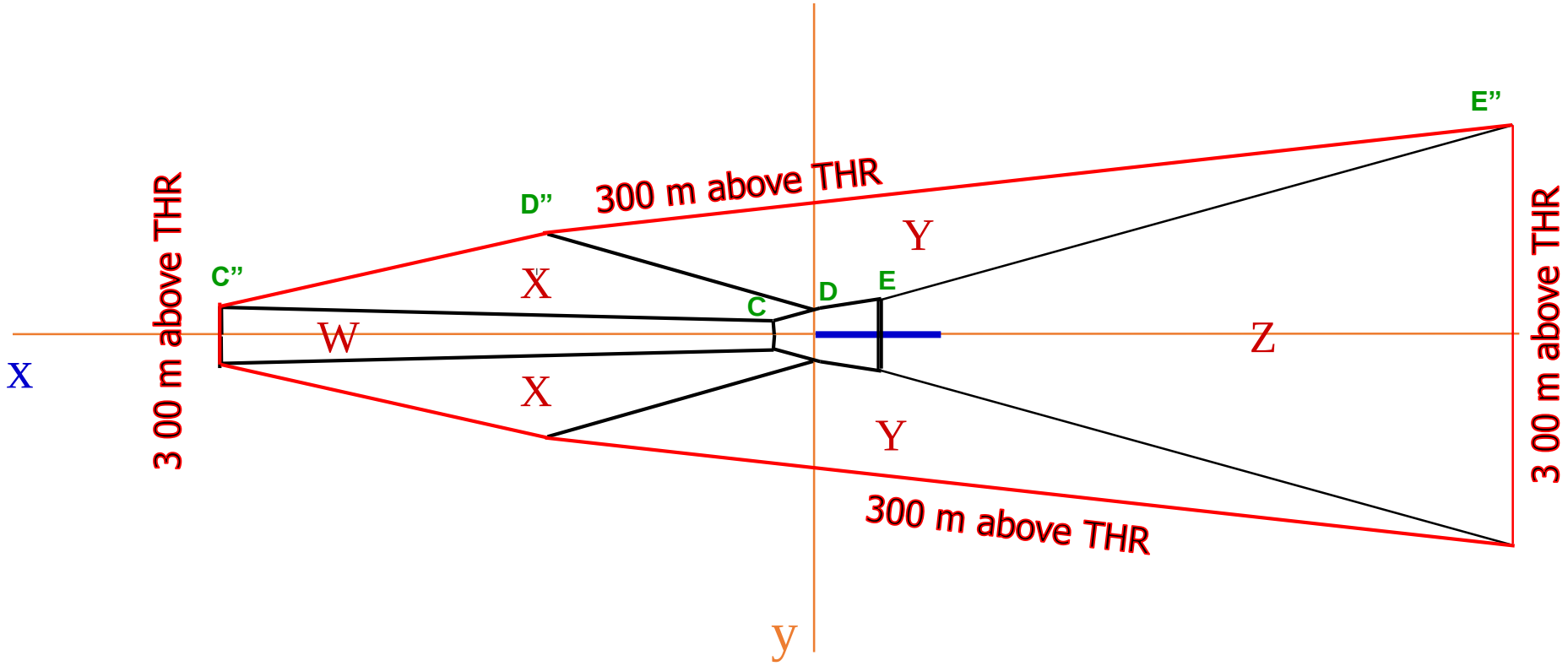
## Obstacle Assessment Surfaces (OAS) template

- 6 Sloping planes surfaces named :
  - one“W”,
  - Two“X”,
  - Two“Y”,
  - One “Z”
- 1 Horizontal plane containing landing THR



# OAS template

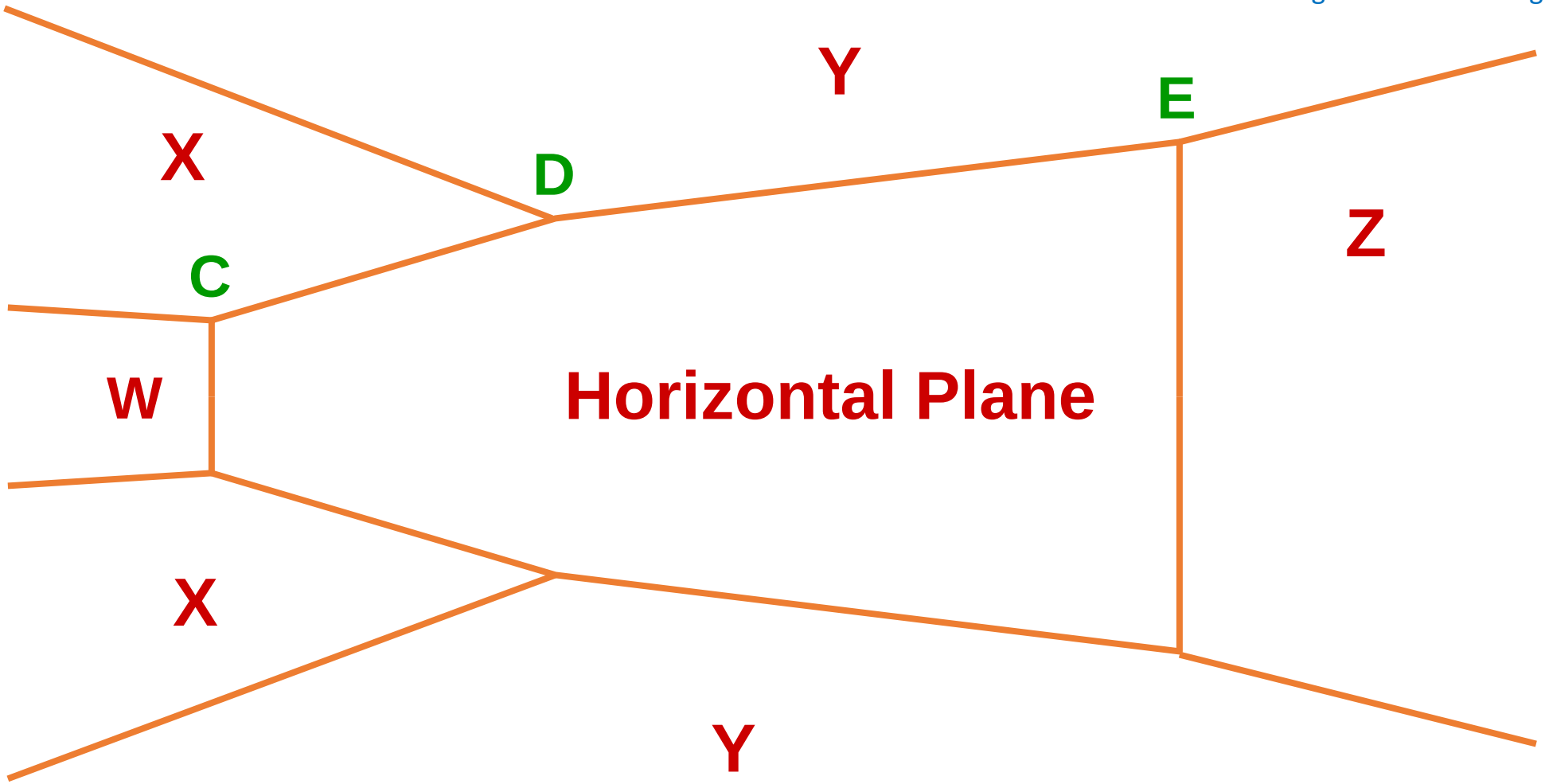





OAS template : W, X, Y, Z surfaces cut 300 m above THR

# OAS Horizontal plane





# OAS obstacle assessment

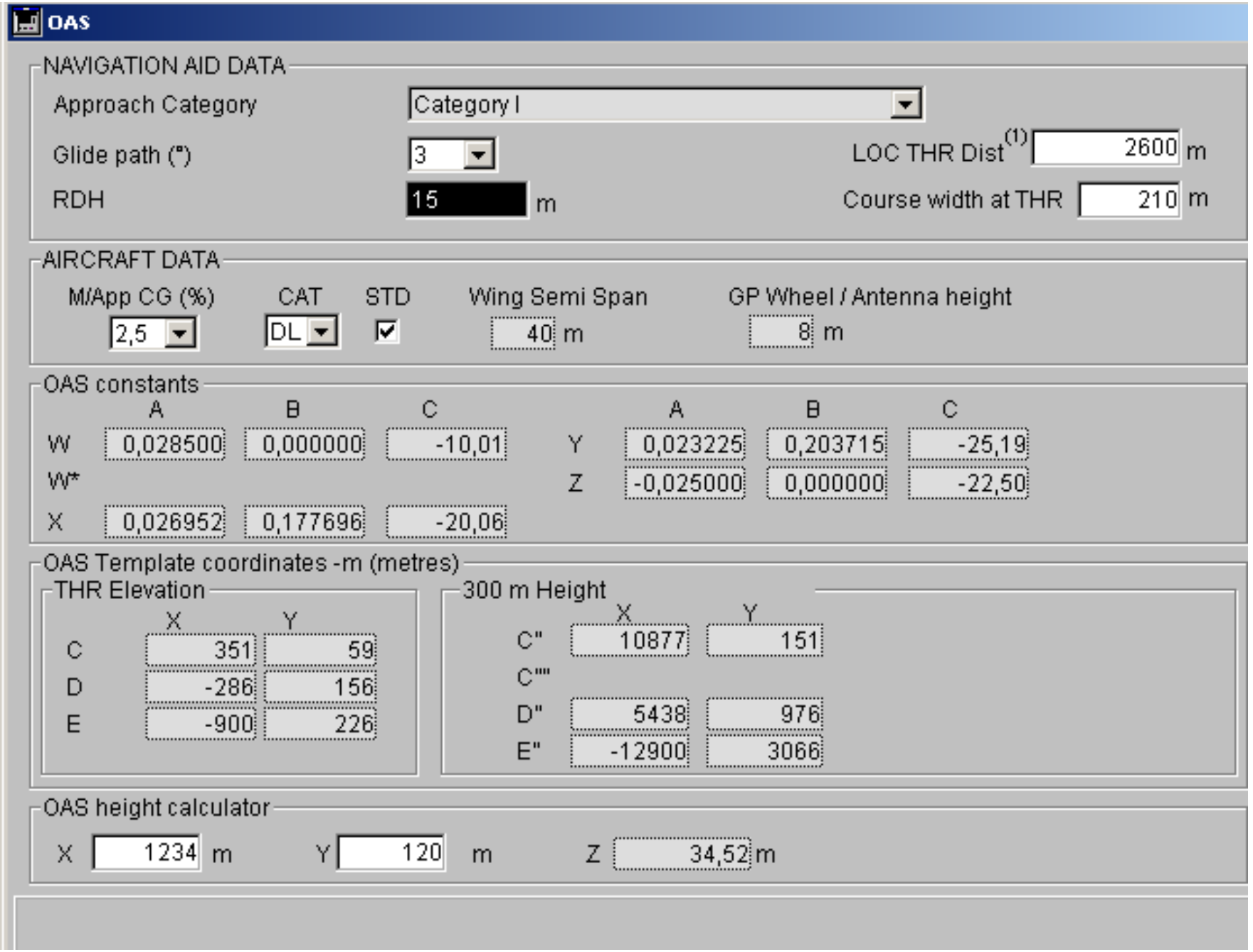


- Obstacle positions expressed in the ILS coordinates system;
- For each plane, z the height of the plane expressed using the OAS equation:
  - ☞ $z = A x + B y + C$
    - Where:
      - z: height above threshold of the plane at position (X,Y);
      - A, B & C: OAS constants depending on:
        - ✓Localizer to threshold distance;
        - ✓Glide path elevation angle;
        - ✓Missed approach gradient of climb;
        - ✓Aircraft specific dimensions (category).
  - ☞ Y is always counted positive.

# OAS obstacle assessment: OAS constants



- Standard values provided in Doc. 8168, vol. 2:
  - C, D, E, C”, D” and E” coordinates;
- A, B and C provided by the PANS-OPS software.
- Data tabulated for:
  - Distance LOC-THR between 2 000 m and 4 500 m (200 m);
  - Glide path angle between 2.5°and 3.5° (0.1° step).
- Missed approach climbing slope:
  - Between 2.5% and 5%;
  - ICAO PANS-OPS software provides A, B, C, C”, D”, E” and OCH.




Last version (3.3) not compatible with Window 10!

# OAS obstacle assessment: OAS constants adjustments

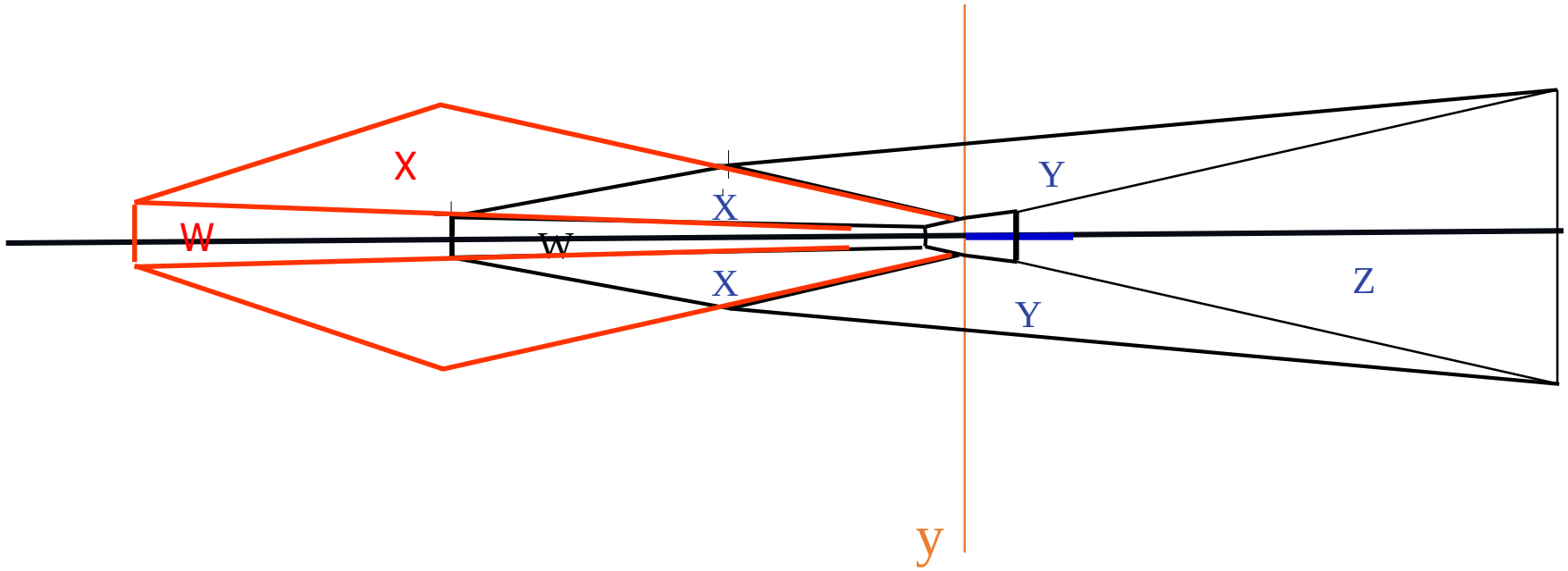


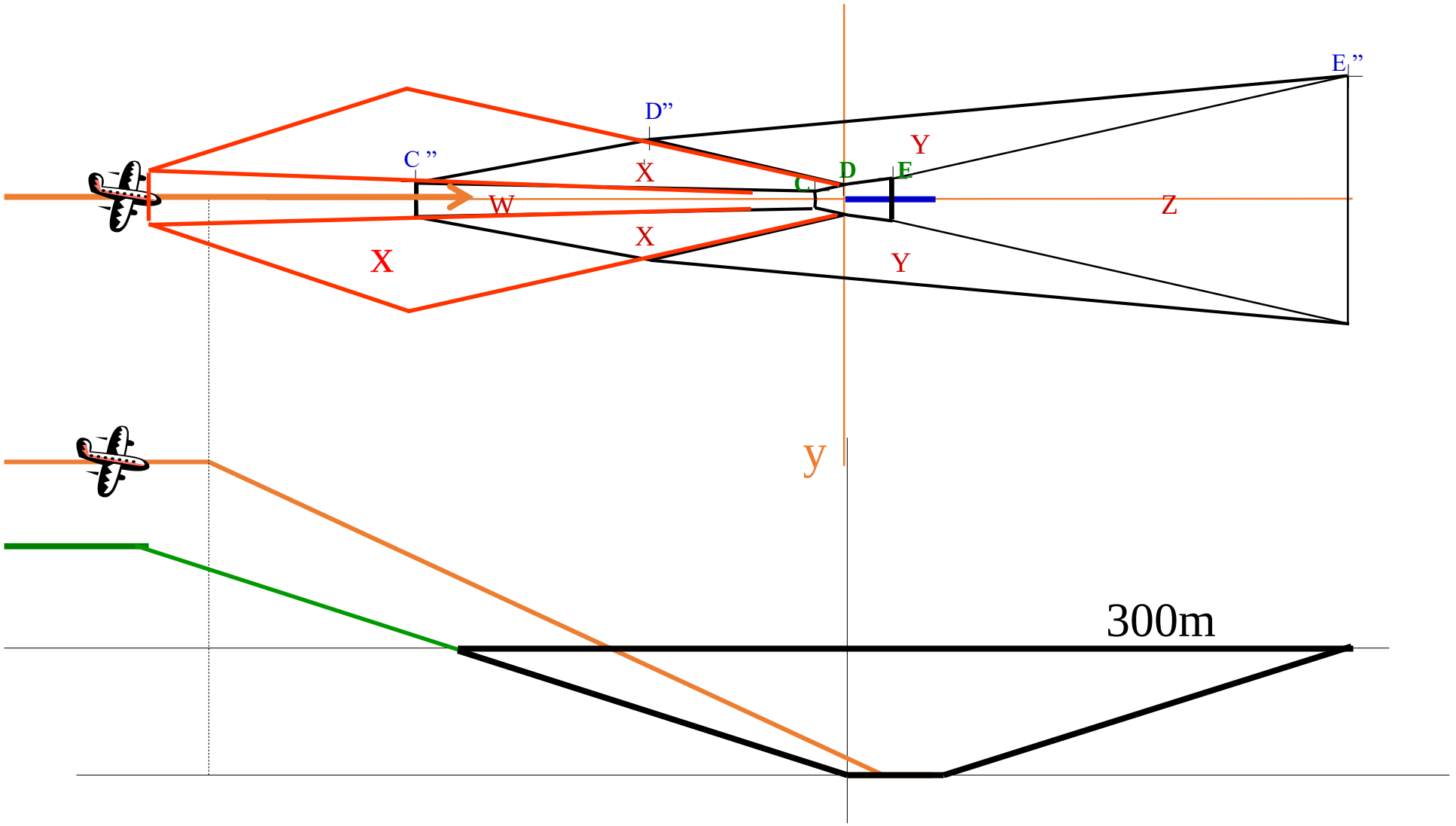
- PANS-OPS software adjusts constants:
  - For requested Aircraft category (from A to $D_L$);
  - None standard aircraft critical dimensions;
  - For requested RDH within (12 m to 18 m);
  - For requested missed approach slope:
    - 2.0 %, 2.5%, 3.0%, 4.0%, 5.0%.
- For Cat. I LOC with course width greater than 210 m:
  - CRM method shall be used.

# OAS obstacle assessment: OCH computation



- OAS extension:
  - Y and Z surfaces always limited to 300 m above THR;
  - W and X surfaces MUST be extended to intermediate protection area plane surface.





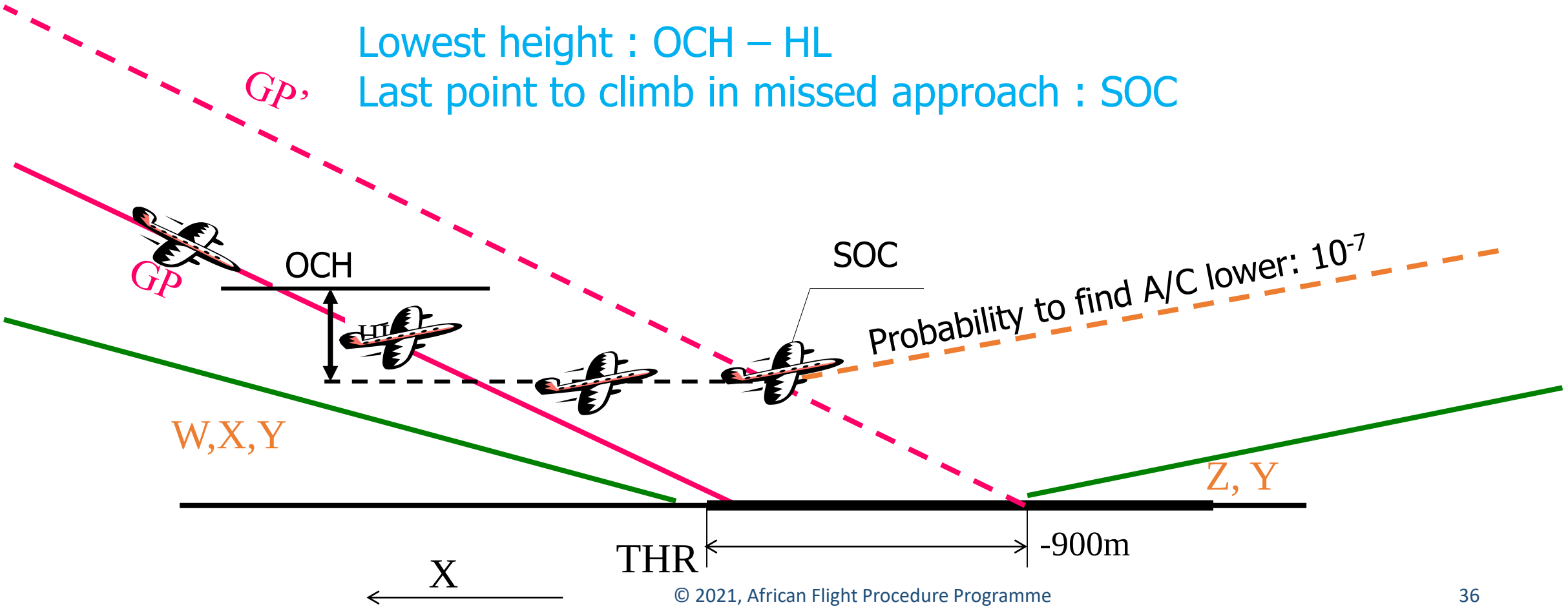
# OAS obstacle assessment: OCH computation



## Start Of Climb (SOC) position

Lowest height : OCH – HL

Last point to climb in missed approach : SOC



# OAS obstacle assessment: OCH computation

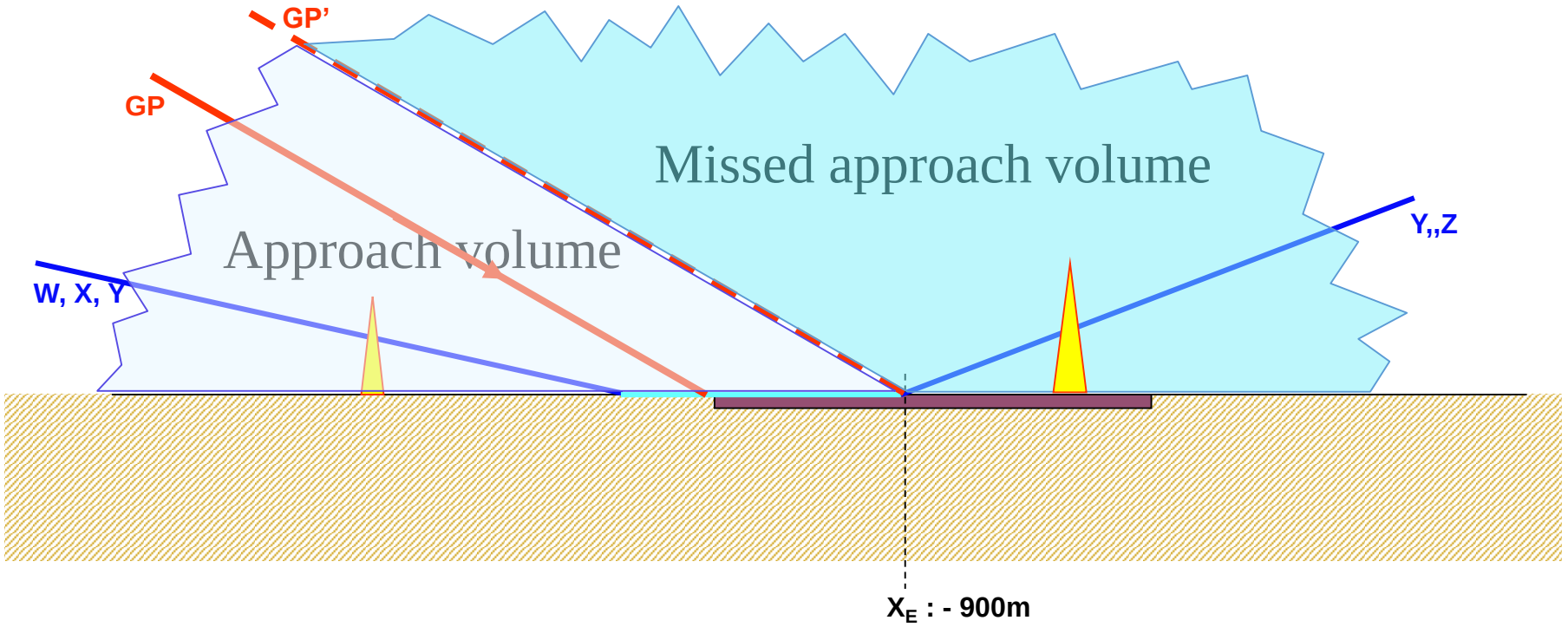


- Main principles for OCH computation:
  - Draw extended OAS from OAS template;
  - Use of Height Loss (HL);
  - No MOC;
  - Airspace divided into :
    - Final volume and
    - Missed approach volume.

# OAS obstacle assessment: OCH computation



## Airspace division in precision approach



# OAS obstacle assessment: OCHps computation



## OCHps computation process

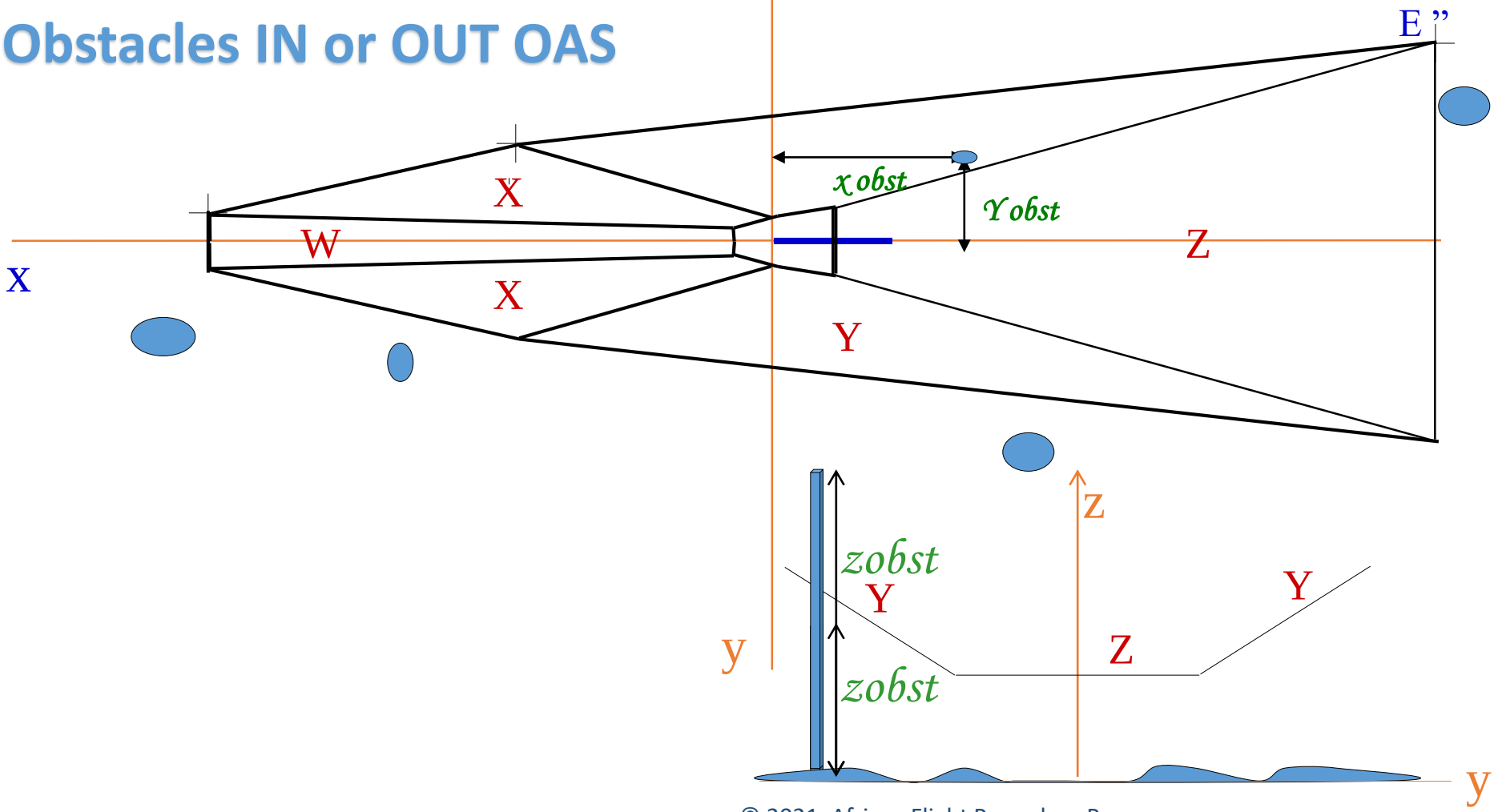
- First step :
  - List all obstacles penetrating OAS surfaces (for exemption, see basic ILS surfaces).
- Second step : Identify:
  - Obstacle in final volume;
  - Obstacle in missed approach volume.
- Third step :
  - Compute OCH for each obstacle.

- OCH of precision segment (OCHps) is the highest value of all obstacle OCHs.

# OAS obstacle assessment: OCHps computation



## Obstacles IN or OUT OAS



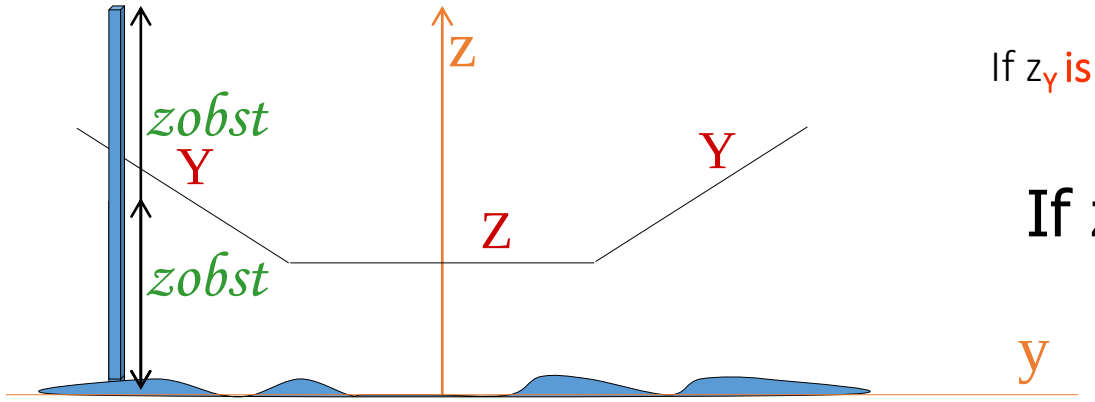
# OAS obstacle assessment: OCHps computation



## Obstacles IN or OUT OAS

In **Y** equation : $z_Y = A_{Yx}\ xobst + B_{Yx}\ yobst + C_Y$

$z_Y$ represents the height of Y plane **(in meter)** at *obstacle* location




If $z_Y$ is greater than *zobst* ➔ *the obstacle* is OUT of OAS

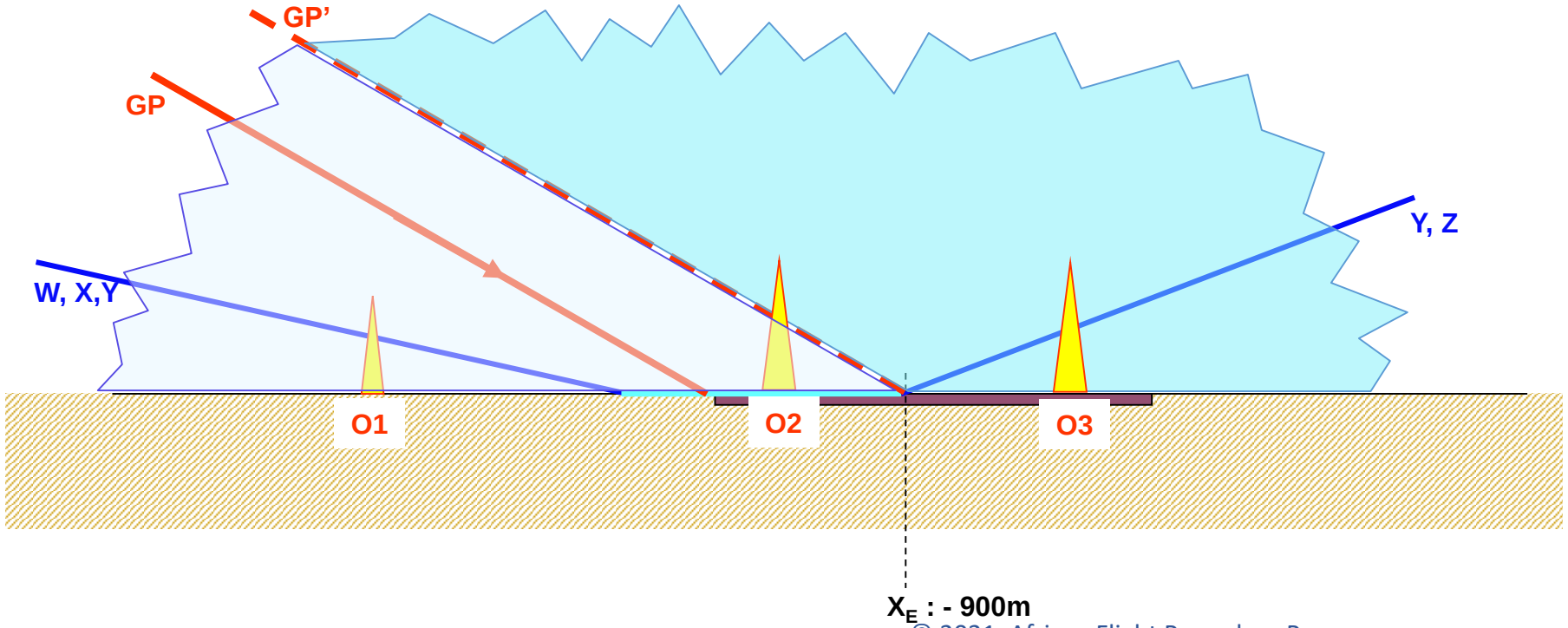
If $z_Y$ **is less than** *zobst* ➔ *the obstacle* is IN the OAS

# Approach obstacles vs Missed approach obstacles



Approach obstacles if
ho $\leq$ **(x - $X_E$) tan $\alpha$**

Missed approach obstacles if
ho $>$ **(x - $X_E$) tan $\alpha$**



# Approach obstacles vs Missed approach obstacles

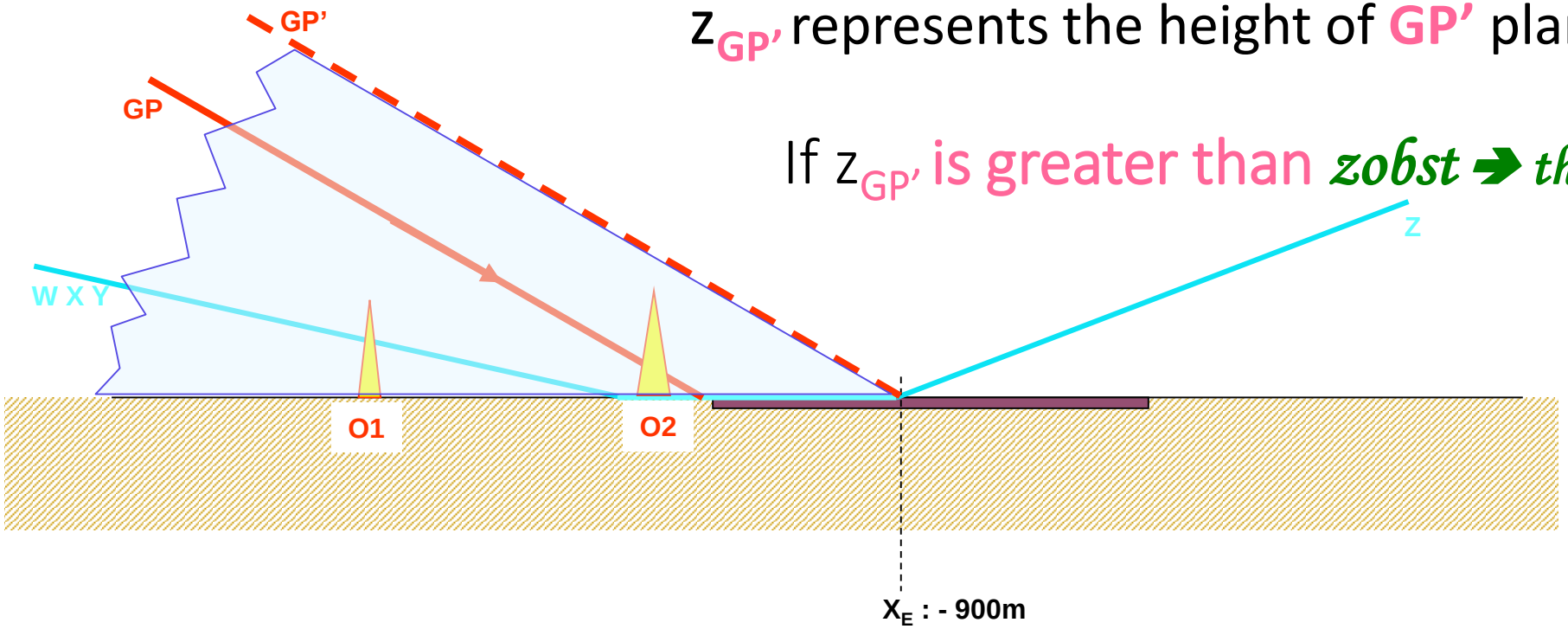


## Obstacle in Final (or in approach): IN OAS and below GP'

GP' equation : $z_{GP'}$ = TAN (GP angle °) x ($x$ - $X_E$)

$z_{GP'}$ represents the height of GP' plane (in m) at *obstacle*

If $z_{GP'}$ is greater than *zobst* ➔ *the obstacle* is in FINAL

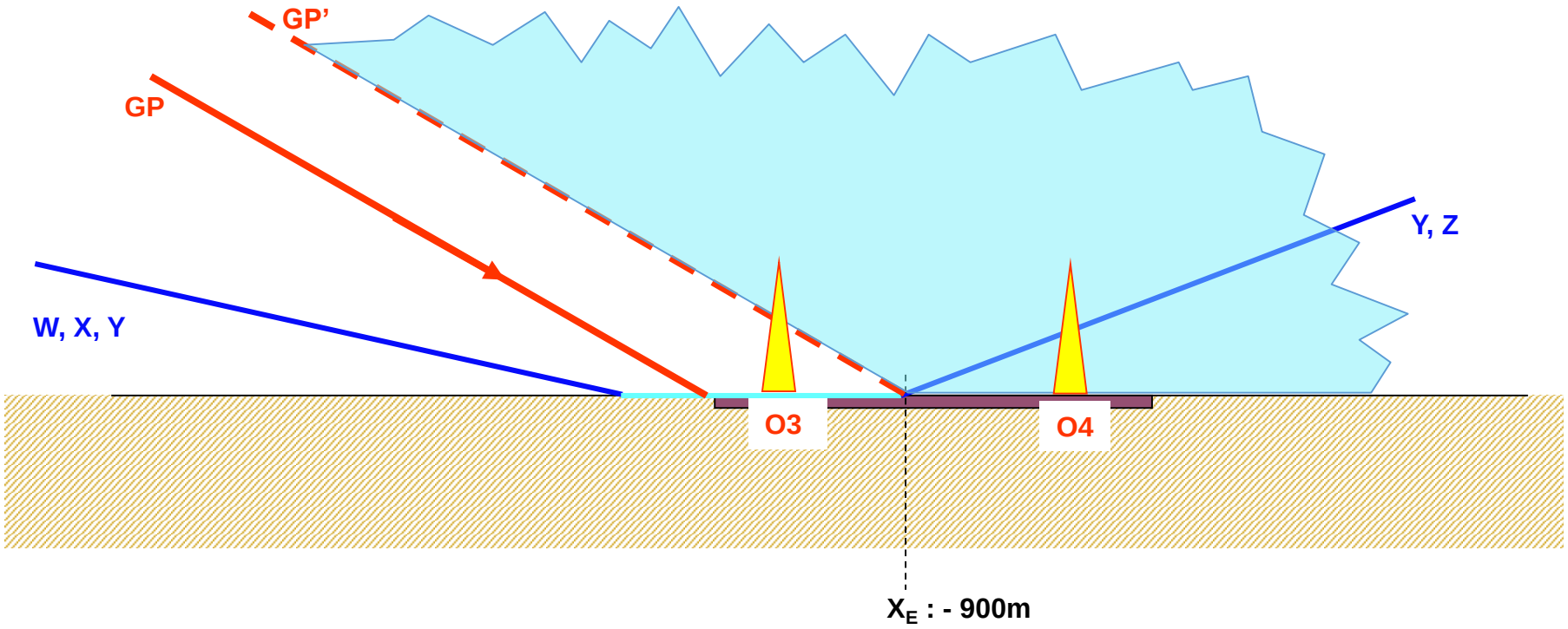


# Approach obstacles vs Missed approach obstacles



## Obstacle in missed approach) if:

### Obstacle in Missed approach if $Z_{GP'} < Z_{obst}$



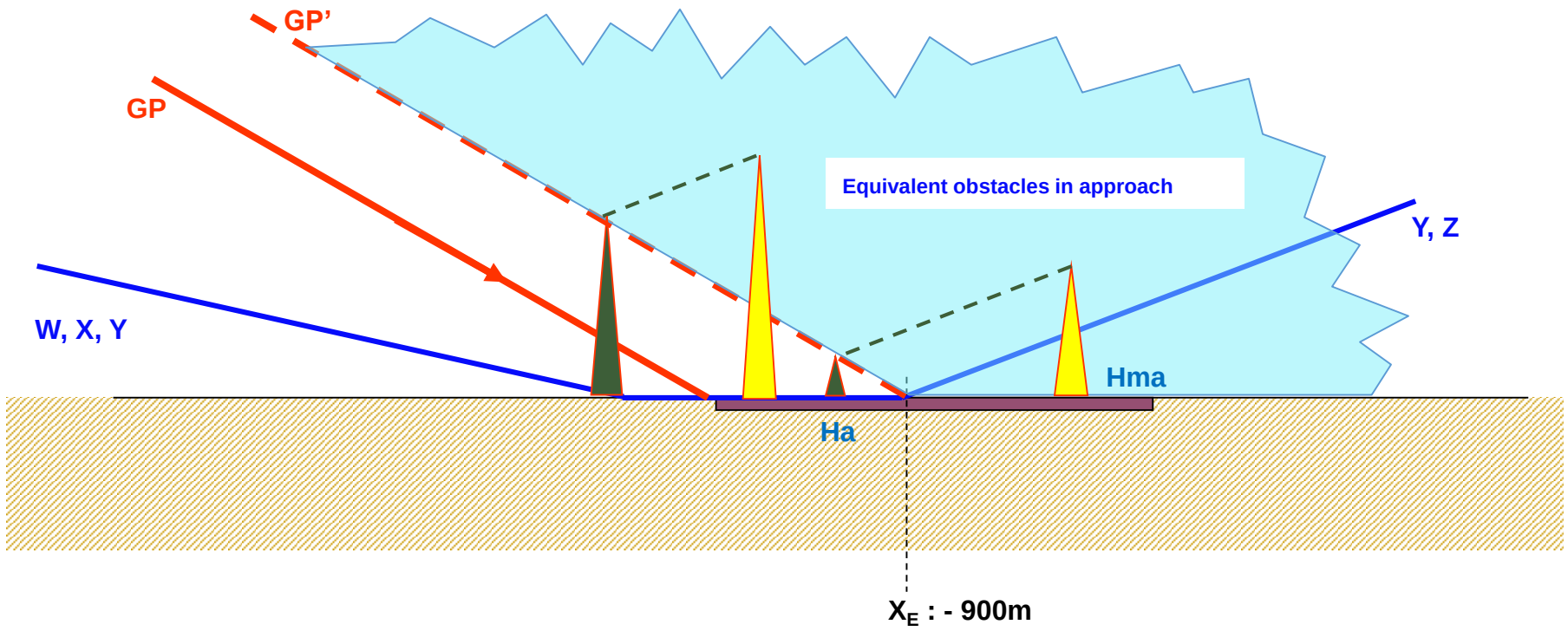

GP' equation : $z_{GP'} = TAN(GPangle^{\circ}) \times (x - X_E)$

$z_{GP'}$ represents the height of GP' plane at *obstacle* location

# Approach obstacles vs Missed approach obstacles



Obstacle in missed approach (hma) can be **converted** into obstacle in final approach (ha) to be comparable with obstacle **actually** in final



# Approach obstacles vs Missed approach obstacles



## Conversion formula

$$h_a = \frac{h_{ma}(Cot(Z°) + (Xobst - XE)}{Cot(Z°) + Cot(GP\ angle°)}$$

**Where:**

- $h_a$ : height of the equivalent approach obstacle;
- $X_E$ = - 900 m;

- X can be positive or negative (unit in always meter);
- Always use the formula with the obstacle heights.

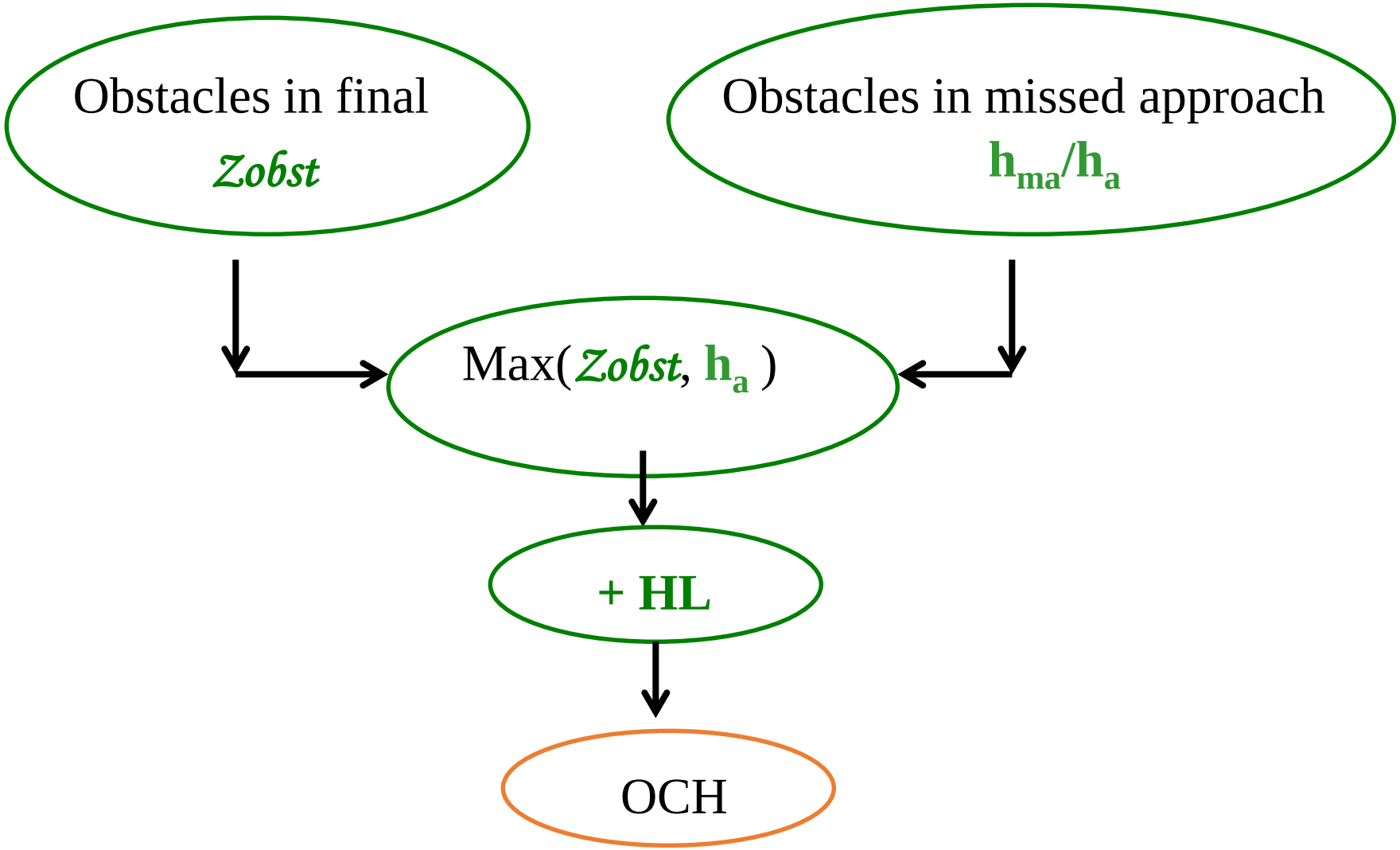
# Approach obstacles vs Missed approach obstacles



## Computation of OCHps

- Obstacles divided in:
  - Approach obstacles;
  - Missed approach obstacles:
    - Replaced by “equivalent approach obstacles “

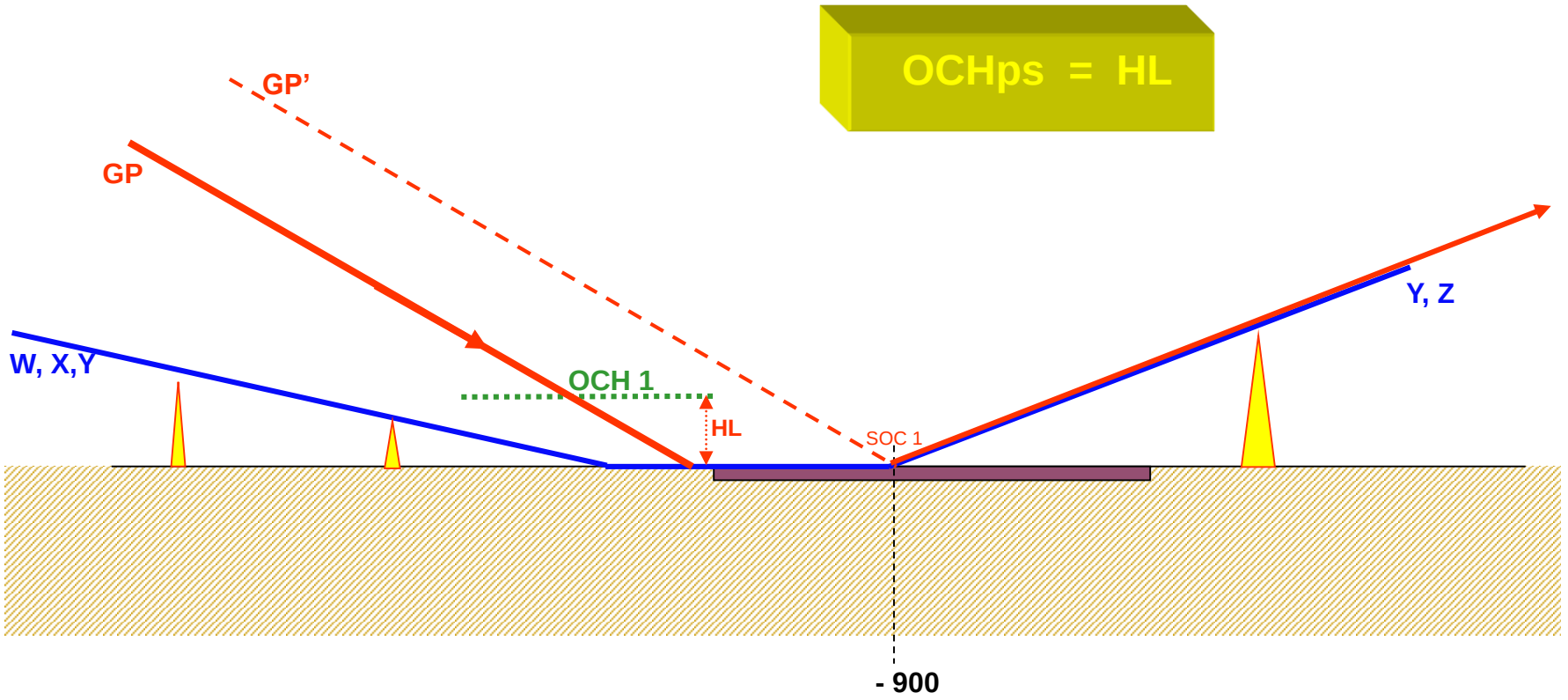
O.C.H.ps = Highest obstacle (real or equivalent) + HL



# Approach obstacles vs Missed approach obstacles



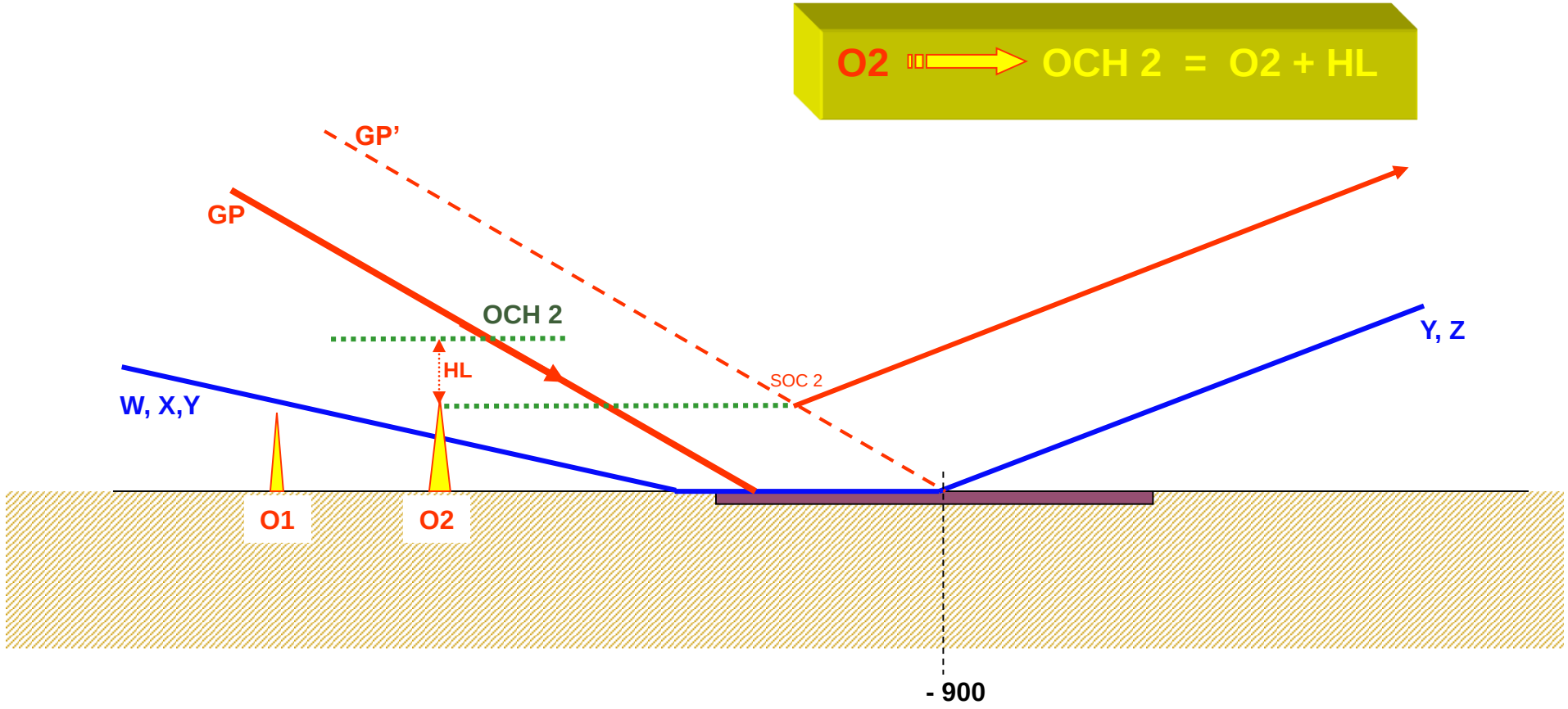
## OCHps computation if no penetrating obstacle



# Approach obstacles vs Missed approach obstacles



## OCHps computation: obstacle in final



# PA initial and intermediate segments

# Initial approach segment



- General criteria apply, except for alignment and protection criteria:
  - The initial segment can be RNAV or RNP 1.
- Alignment with the intermediate segment (turn angle):
  - Maximum: 90°;
  - Optimum: 30°;
  - For turn > 70°:
    - Lead information (radial, bearing, radar vector or DME distance): 2 NM before the turn (1 NM for Cat. H).
  - For turn > 90°:
    - Reversal or racetrack procedure od DR procedure.

# Intermediate approach segment



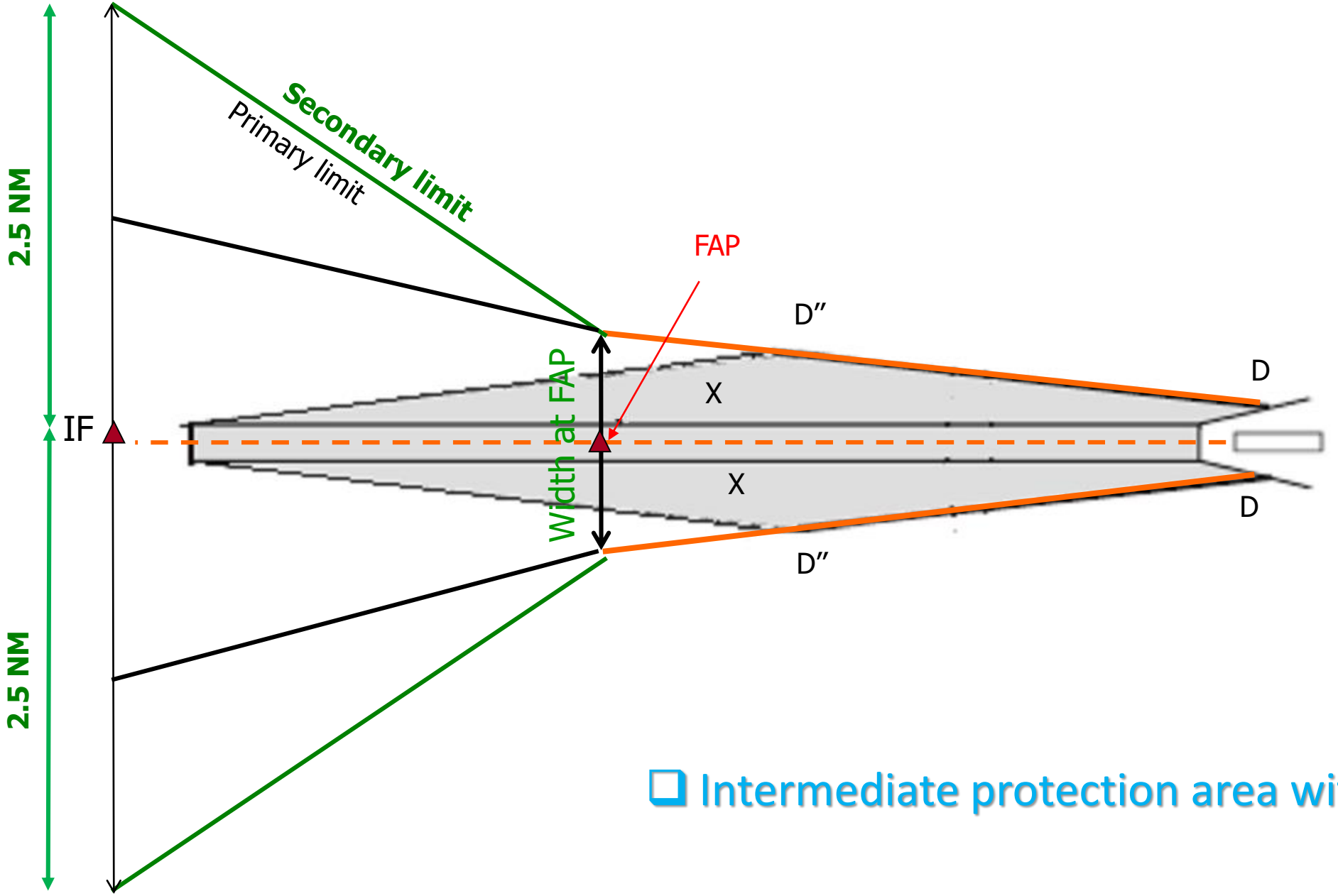
- Mandatory for ILS procedure:
  - With or without IF.
- Alignment with the final approach segment:
  - Not turn allowed at the FAP.
- Length:
  - Optimum: 50 NM;
  - Maximum: IF not more than 25 NM from the LOC antenna;
  - Minimum:
    - Depends on the magnitude of the turn at the IF.

## Minimum distance between IF and FAP (NM)

| Angle of turn at IF | Cat. A –B | Cat. C-D |
|---|---|---|
| [0°;15°] | 1.5 | 1.5 |
| [16°;30°] | 2.0 | 2.0 |
| [31°;60°] | 2.0 | 2.5 |
| [61°;90°] | 2.0 | 3.0 |

# Intermediate approach segment

- Protection with IF:
  - At the IF:
    - Total width : 5 NM
  - At the end of intermediate segment
    - Total width :
      - Width of OAS X surfaces at the FAP;
      - Only primary area.



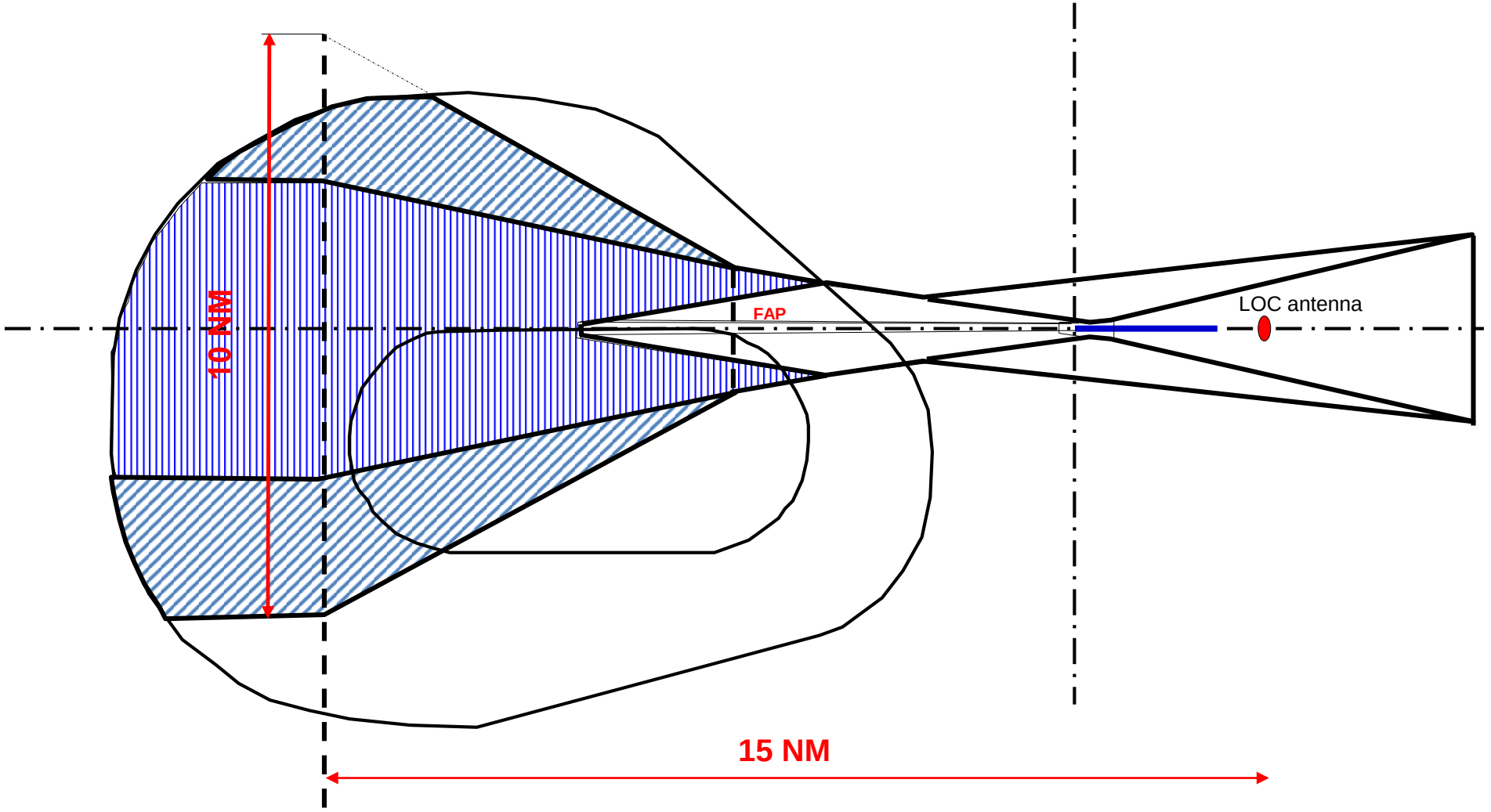

❑ Intermediate protection area with IF

# Intermediate approach segment



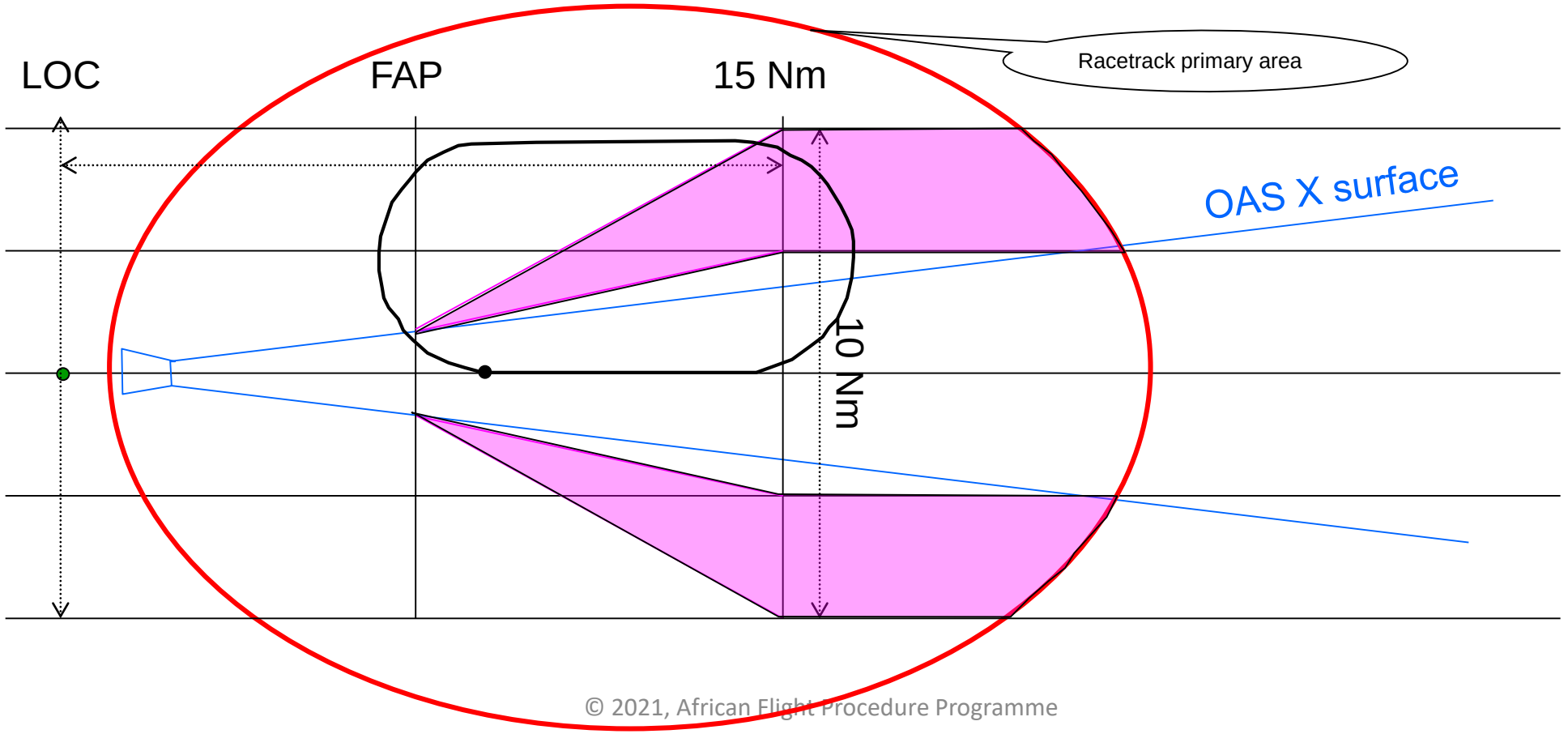
- Protection without IF:
  - Racetrack or reversal turn;
  - Estimated width of LOC guidance:
    - 15 NM from LOC antenna;
    - +/- 5 NM ;
    - Primary and secondary areas.
  - Width at FAP :
    - X surfaces width;
    - No more secondary area.
  - Protection area:
    - Intersection of:
      - LOC guidance protection area;
      - Racetrack /reversal primary protection area.

# Intermediate with initial based on racetrack far from LOC

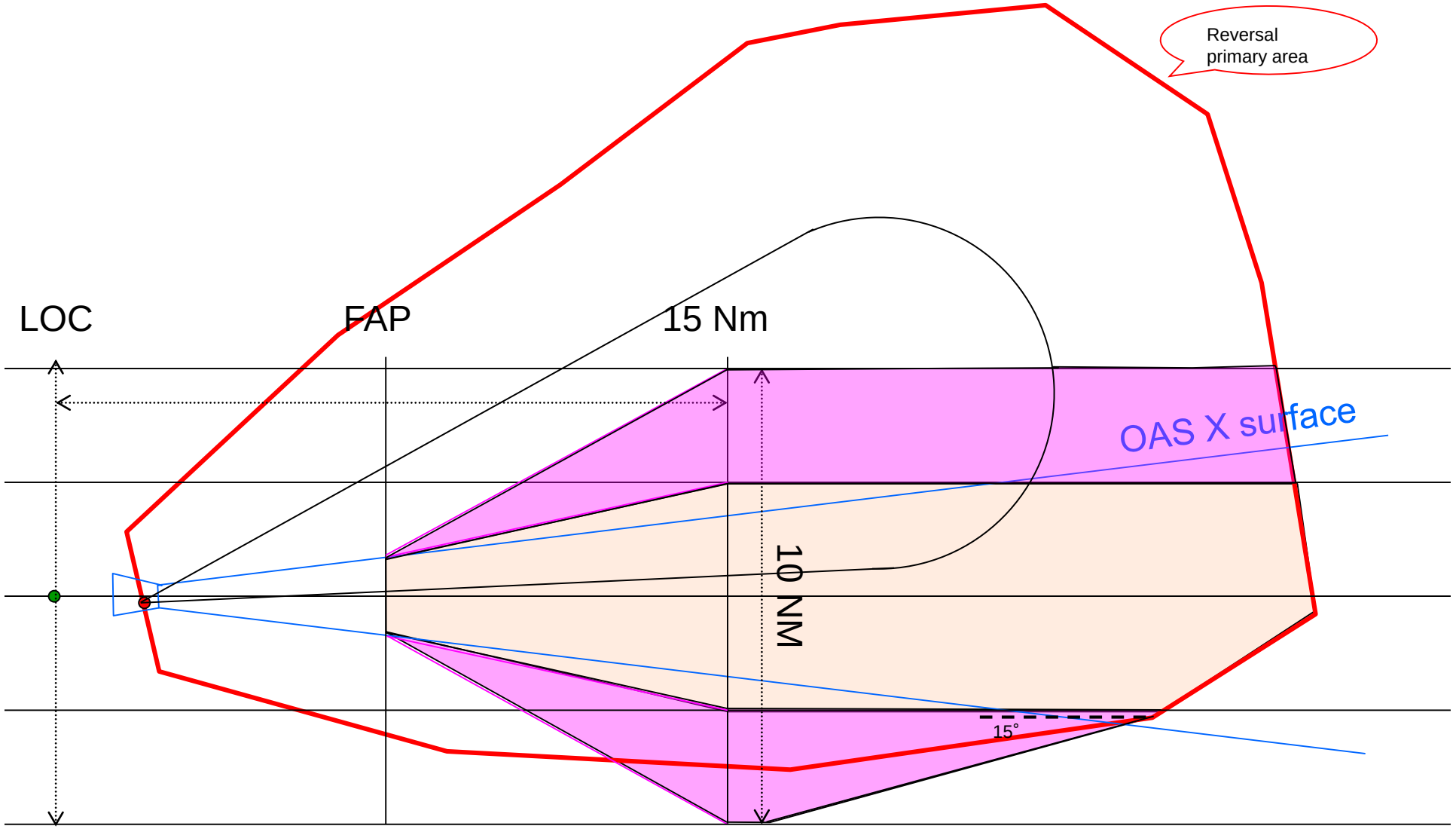


# Intermediate Area connection with racetrack

- The intermediate area  extends 5 NM on each side  at 15 NM from LOC and tapers uniformily to the width at FAP
- Intermediate is divided into two equal part primary and secondary
- When no IF the area extends to the far boundary of the reversal primary area
- § II-3-4-4  and § I-4-4-3 § I-4-4-4



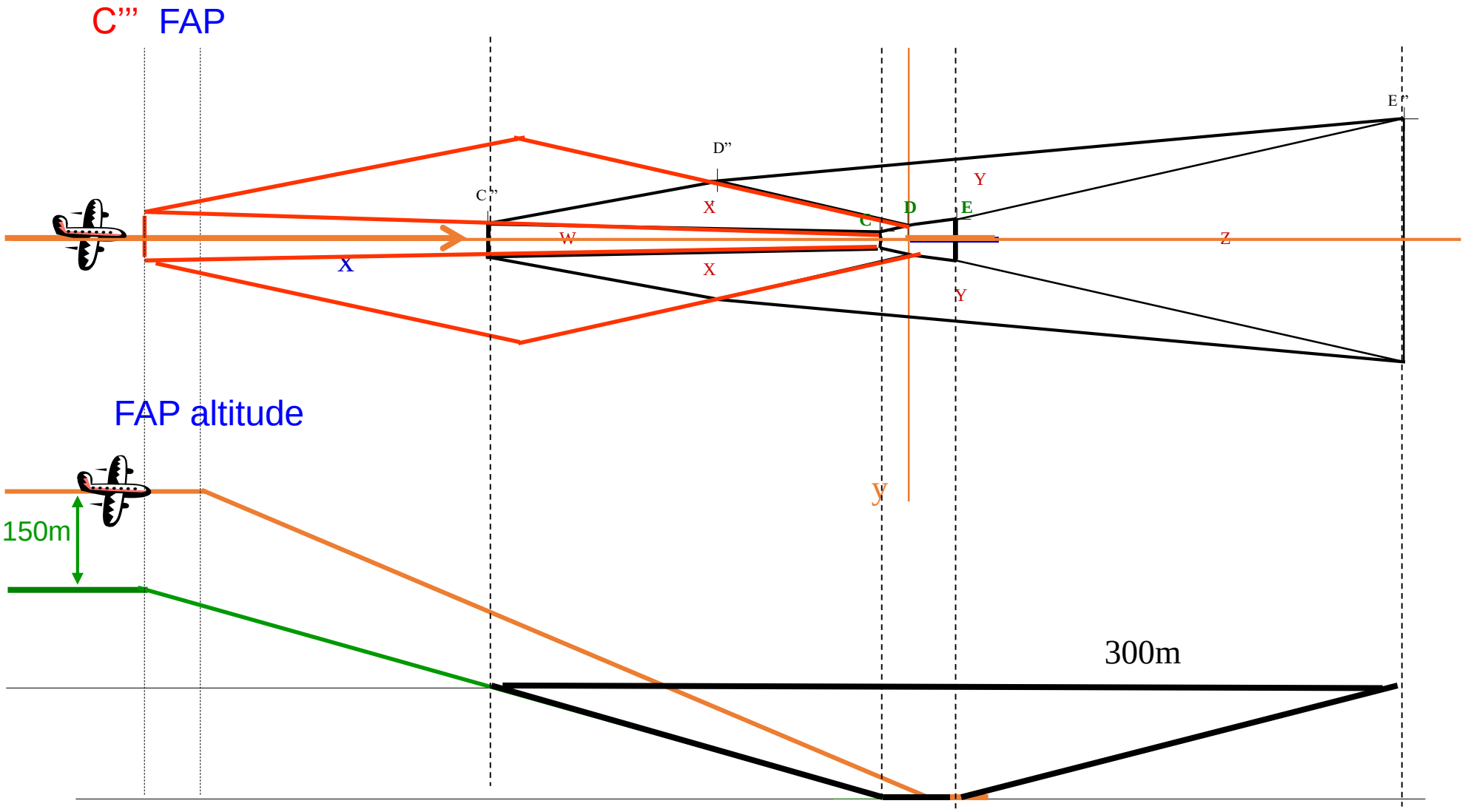
# Intermediate Area connection with reversal



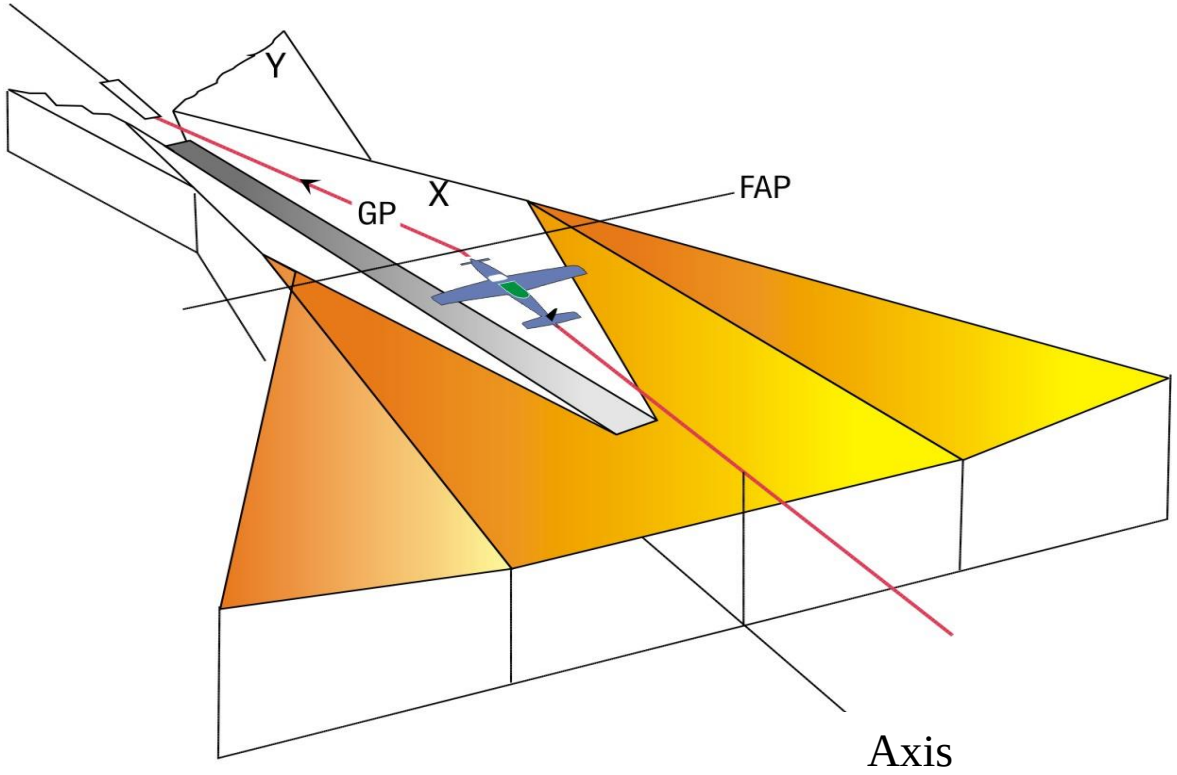
## Obstacle assessment extended surfaces

- W and X surfaces MUST be extended to intermediate protection area plane surface
- 150 m below FAP altitude
- Protection:
  - ☞Standard MOC : 150 m;
  - ☞Some obstacles assessed twice:
    - for intermediate protection area;
    - for OAS extended surfaces.

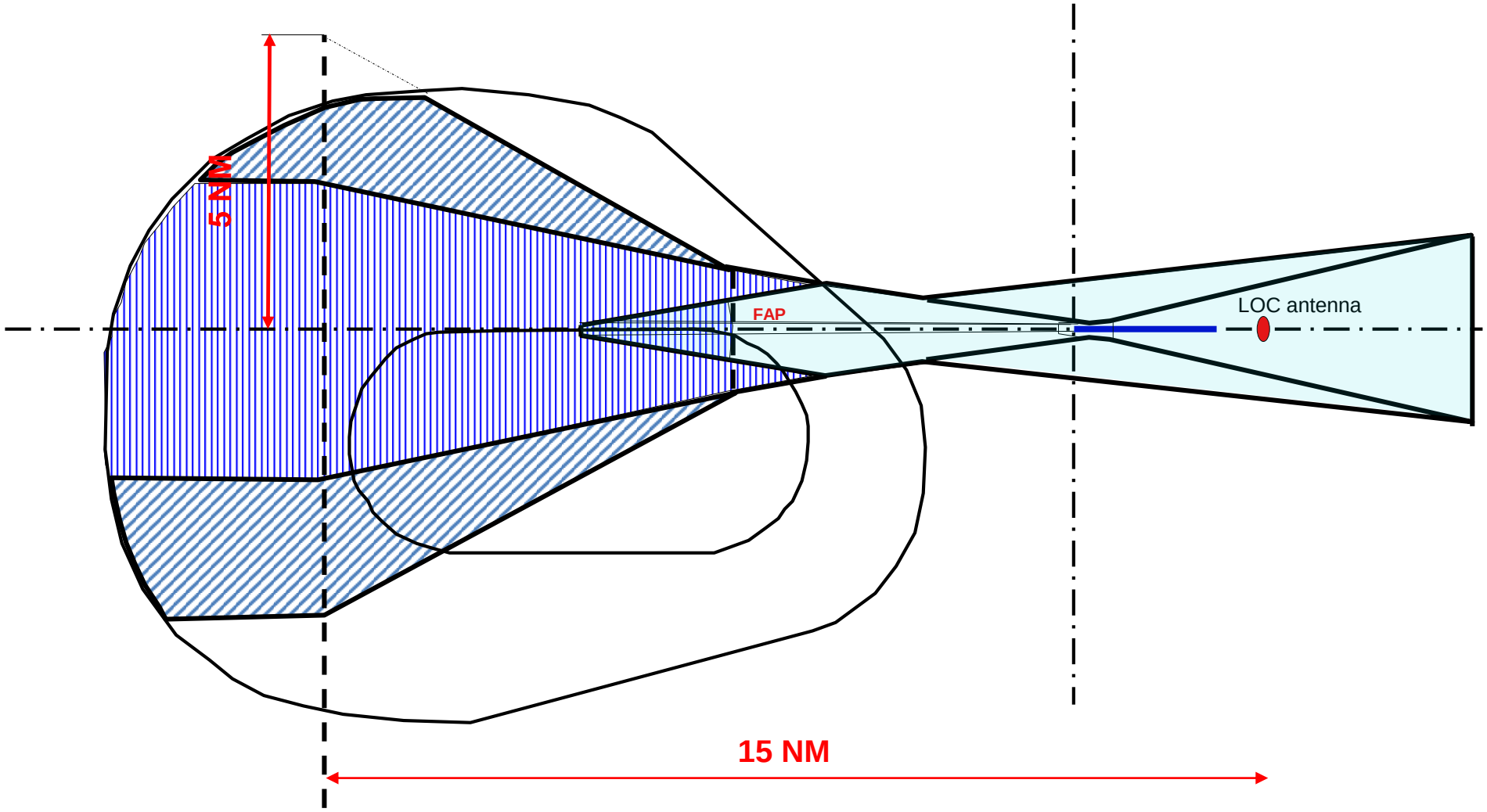
# Connection from OAS template to intermediate segment: Extented surfaces



# Overlapping protection areas



# Intermediate area / extended final surfaces




# Questions:

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