SBAS NPA, APV and Precision Approach CAT I
Target:

Learn basic concept on SBAS non precision approach, approach with vertical guidance and precision approach category I procedures.
Concepts

- **Part 1**: General Concepts
- **Part 2**: Initial and Intermediate approach segments
- **Part 3**: APV Segment
- **Part 4**: Missed Approach
- **Part 5**: SBAS Approach with OFFSET track alignment
- **Part 6**: SBAS NPA
- **Part 7**: Promulgation
Part 1
General Concepts
General Concepts

SBAS stands for Satellite Based Augmentation System and it’s a concept based on GNSS measurements by accurately-located reference stations deployed across an entire continent. The GNSS errors are then transferred to a computing centre, which calculate differential corrections and integrity messages which are then broadcasted over the continent using geostationary satellites as an augmentation or overlay of the original GNSS message. SBAS messages are broadcast via geostationary satellites able to cover vast areas.
All of the systems comply with a common global standard and are therefore all compatible (do not interfere with each other) and interoperable (a user with a standard receiver can benefit from the same level of service and performance whether located in the EGNOS or WAAS coverage area).
General Concepts

SBAS benefits

Enhance the performance of GPS in terms of:

- Accuracy
- Availability
- Continuity
- Integrity

In aviation ....

- SBAS increases the GPS performances to provide pilots with usable glide slopes information (APV).

- The SBAS vertically guided approach procedures are considered LPV (Localizer Performance with Vertical guidance) and provide ILS (Instrument Landing System) equivalent approach minima as low as 200 feet at qualifying airports. Actual minimums are based on an airport’s current infrastructure, as well as an evaluation of any existing obstructions.
General Concepts

Instrument flight procedure using Satellite Based Augmentation System are classified as follow:

**APV**
Approach procedure with vertical guidance (APV). A performance-based navigation (PBN) instrument approach procedure designed for 3D instrument approach Type A.

**SBAS CAT I**
A precision approach procedure based on navigation systems SBAS Cat I designed for 3D instrument approach operations Type A or B.

*Note (from annex 6 – part II – Chapter 2, par. 2.2.2.2.2 ):*
Instrument approach operations shall be classified based on the designed lowest operating minima below which an approach operation shall only be continued with the required visual reference as follows:

**Type A**: A minimum descent height or decision height at or above 75 m (250 ft); and
**Type B**: A decision height below 75 m (250 ft) – (i.e CAT I, CAT II, CAT II A/B/C)
General Concepts

Since vertical guidance is provided, APV procedures are considered 3D procedures. In fact, in the final segment, a Vertical Path Angle (VPA) is computed by the system. The VPA is calculated between the FAP and the LTP considering a RDH (Reference DATUM Height) of 15m.

Intermediate OCA

FAP

RHD (Reference Datum Height) is 15 m above the LTP

LTP

Landing Threshold Point

Θ = VPA = Vertical Path Angle (computed by the system)
In the OCA/H box of an RNAV approach chart, when SBAS procedure are implemented, in most of the cases, three different minima are depicted.

**General Concepts**

**RNAV**
- Uses Basic GNSS or SBAS in NPA mode
- **APV Baro VNAV minima**: RNP APCH + Baro VNAV equipment
- **RNAV**: Uses Basic GNSS or SBAS in NPA mode

**LPV (Localizer Performance with Vertical Guidance)**: minima associated with SBAS APV I / II performances on approach.
General Concepts

**APV I and APV II:** The differences lie in the signal-in-space performance requirements *(below the references from ANNEX 10)*

### Annex 10 — Aeronautical Communications

#### Table 3.7.2.4-1 Signal-in-space performance requirements

<table>
<thead>
<tr>
<th>Typical operation</th>
<th>Accuracy horizontal 95% (Notes 1 and 3)</th>
<th>Accuracy vertical 95% (Notes 1 and 3)</th>
<th>Integrity (Note 2)</th>
<th>Time-to-alert (Note 3)</th>
<th>Continuity (Note 4)</th>
<th>Availability (Note 5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>En-route</td>
<td>3.7 km (2.0 NM)</td>
<td>N/A</td>
<td>$1 - 1 \times 10^{-7}$ h</td>
<td>5 min</td>
<td>$1 - 1 \times 10^{-7}$ h to $1 - 1 \times 10^{-3}$ h</td>
<td>0.99 to 0.9999997</td>
</tr>
<tr>
<td>En-route, Terminal</td>
<td>0.74 km (0.4 NM)</td>
<td>N/A</td>
<td>$1 - 1 \times 10^{-7}$ h</td>
<td>15 s</td>
<td>$1 - 1 \times 10^{-7}$ h to $1 - 1 \times 10^{-3}$ h</td>
<td>0.99 to 0.9999997</td>
</tr>
<tr>
<td>Initial approach, Intermediate approach, Non-precision approach (NPA), Departure</td>
<td>220 m (720 ft)</td>
<td>N/A</td>
<td>$1 - 1 \times 10^{-7}$ h</td>
<td>10 s</td>
<td>$1 - 1 \times 10^{-7}$ h to $1 - 1 \times 10^{-3}$ h</td>
<td>0.99 to 0.9999997</td>
</tr>
<tr>
<td>Approach operations with vertical guidance (APV-I)</td>
<td>16.0 m (52 ft)</td>
<td>20 m (66 ft)</td>
<td>$1 - 2 \times 10^{-7}$ h in any approach</td>
<td>10 s</td>
<td>$1 - 8 \times 10^{-6}$ per 13 s</td>
<td>0.99 to 0.9999997</td>
</tr>
<tr>
<td>Approach operations with vertical guidance (APV-II)</td>
<td>16.0 m (52 ft)</td>
<td>8.0 m (26 ft)</td>
<td>$1 - 2 \times 10^{-7}$ h in any approach</td>
<td>6 s</td>
<td>$1 - 8 \times 10^{-6}$ per 15 s</td>
<td>0.99 to 0.9999997</td>
</tr>
</tbody>
</table>

**NOTES**

1. The 95th percentile values for GNSS position errors are those required for the intended operation at the lowest height above threshold (HAT), if applicable. Detailed requirements are specified in Appendix B and guidance material is given in Attachment D, 3.2.
2. The definition of the integrity requirement includes an alert limit against which the requirement can be assessed. For Category I precision approach, a vertical alert limit (VAL) greater than 10 m for a specific system design may only be used if a system-specific safety analysis has been completed. Further guidance on the alert limits is provided in Attachment D, 3.3.6 to 3.3.10. These alert limits are:
# General Concepts

<table>
<thead>
<tr>
<th>Typical operation</th>
<th>Horizontal alert limit</th>
<th>Vertical alert limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>En-route (oceanic/continental</td>
<td>7.4 km (4 NM)</td>
<td>N/A</td>
</tr>
<tr>
<td>low density</td>
<td></td>
<td></td>
</tr>
<tr>
<td>En-route (continental)</td>
<td>3.7 km (2 NM)</td>
<td>N/A</td>
</tr>
<tr>
<td>En-route, Terminal</td>
<td>1.85 km (1 NM)</td>
<td>N/A</td>
</tr>
<tr>
<td>NPA</td>
<td>556 m (0.3 NM)</td>
<td>N/A</td>
</tr>
<tr>
<td>APV-I</td>
<td>40 m (130 ft)</td>
<td>50 m (164 ft)</td>
</tr>
<tr>
<td>APV-II</td>
<td>40 m (130 ft)</td>
<td>20.0 m (66 ft)</td>
</tr>
<tr>
<td>Category I precision approach</td>
<td>40 m (130 ft)</td>
<td>35.0 m to 10.0 m (115 ft to 33 ft)</td>
</tr>
</tbody>
</table>

3. The accuracy and time-to-alert requirements include the nominal performance of a fault-free receiver.

4. Ranges of values are given for the continuity requirement for en-route, terminal, initial approach, NPA and departure operations, as this requirement is dependent upon several factors including the intended operation, traffic density, complexity of airspace and availability of alternative navigation aids. The lower value given is the minimum requirement for areas with low traffic density and airspace complexity. The higher value given is appropriate for areas with high traffic density and airspace complexity (see Attachment D, 3.4.2). Continuity requirements for APV and Category I operations apply to the average risk (over time) of loss of service, normalized to a 15-second exposure time (see Attachment D, 3.4.3).

5. A range of values is given for the availability requirements as these requirements are dependent upon the operational need which is based upon several factors including the frequency of operations, weather environments, the size and duration of the outages, availability of alternate navigation aids, radar coverage, traffic density and reversionary operational procedures. The lower values given are the minimum availabilities for which a system is considered to be practical but are not adequate to replace non-GNSS navigation aids. For en-route navigation, the higher values given are adequate for GNSS to be the only navigation aid provided in an area. For approach and departure, the higher values given are based upon the availability requirements at airports with a large amount of traffic assuming that operations to or from multiple runways are affected but reversionary operational procedures ensure the safety of the operation (see Attachment D, 3.5).

6. A range of values is specified for Category I precision approach. The 4.0 m (13 feet) requirement is based upon ILS specifications and represents a conservative derivation from these specifications (see Attachment D, 3.2.7).

7. GNSS performance requirements for Category II and III precision approach operations are under review and will be included at a later date.

8. The terms APV-I and APV-II refer to two levels of GNSS approach and landing operations with vertical guidance (APV) and these terms are not necessarily intended to be used operationally.
Part 2
Initial and Intermediate approach segment
Any sensor can be used, the design criteria are the same for PBN arrival and approach procedures specified in Pans Ops *Vol II- Part III-Section 3, Chapter2.*
Any sensor can be used according to the Navigation Specification required for the Intermediate Segment, however, the transition to the SBAS navigation shall be made 2.0 NM prior to the FAF.
The intermediate approach segment of an SBAS procedure shall be aligned with the final approach segment.
Initial and Intermediate approach segments

**Intermediate approach segment: Area Width**

The total area width is as described in Chapter 2, 2.4.3, “Intermediate approach area width”. From 3.7 km (2.0 NM) to the FAF the area tapers uniformly to match the horizontal distance between the SBAS APV OAS X surfaces at the FAF. The secondary area width decreases to zero at the interface with the final approach surfaces.

![Diagram showing intermediate approach area](image-url)

**Figure III-3-5-1 a.** Intermediate approach area (fully based on SBAS). FAF far away from the threshold (X surface width more than 3.7 km (2.0 NM) at the FAF)
Initial and Intermediate approach segments

**Intermediate approach segment : Area Width**

According to the length of the final approach segment, the SBAS APV OAS X surface width at the final approach fix can be less than 1.9 NM. In this case, to provide protection to an aircraft that initiates an early missed approach, a 3.52 km (1.90 NM) value (for helicopters 2.96 km (1.60 NM)) is considered for area width of the intermediate approach segment at the final approach fix).

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**Figure III-3-5-1 b)**. Intermediate approach area (fully based on SBAS). FAF close to the threshold (X surface width less than 3.7 km (2.0 NM) at the FAF)
Part 3
APV Segment
The APV or Category I segment of an SBAS APV I, APV II or Category I approach procedure shall be aligned with the runway centre line and contain the final approach, the initial and the intermediate missed approach segments.
The APV or Category I segment starts at the final approach point (the intersection of the nominal vertical path and the minimum altitude specified for the preceding segment). For navigation database coding purposes, the waypoint located at the FAP shall not be considered as a descent fix. The SBAS OAS surfaces extend into the intermediate approach segment but not beyond this segment.
**APV Segment**

**APV or Category I segment: FAP Calculation**

The method below explains how to calculate the FAP altitude taking into consideration a simple Euclidean triangle. Since the airplane is flying using the barometric altimeter the calculation will not be 100% precise because we are not taking into account the earth curvature correction. Long finals (generally more than 5 NM) require earth curvature correction to adjust XFAS according to FAP altitude or vice versa. Refer to PANS OPS – PART II, SECTION 1, Appendix C to Chpt.1)

\[ X_{Fap} = \frac{\text{Intermediate OCA} - \text{THR elev} - \text{RDH}}{\tan \text{VPA}} \]
APV Segment

**APV or Category I segment: Termination**

The APV or Category I segment terminates at the point where the final phase of the missed approach commences (turning point) or where the missed approach climb surface Z reaches a semi-width of 1.76 km (0.95 NM) (for helicopters 1.48 km (0.8 NM)), whichever occurs first.
APV Segment

APV or Category I segment: Obstacle clearance

The APV segment is protected by a set of 7 sloped surfaces (denoted by letters W,W',X,Y and Z) named SBAS APV OAS or SBAS Category I OAS (ILS like) which are used to compute the OCA/H.

Figure III-3-5-2. Illustration of SBAS APV obstacle assessment surfaces (plan view and profile view)
APV Segment

APV or Category I segment: Obstacle clearance

OAS dimension and slopes depend on:

- GARP (GBAS Azimuth Reference Point) / THR distance
- GP (VPA) (min/opt 3° - MAX 3.5°)
- RDH above nominal value
- Missed Approach Climb Gradient Aircraft dimension
- SBAS Operation (depends on APVI, APV II or Cat I Ops.)

Note: The SBAS Category I OAS contains the following sloping surfaces: W, X, Y and Z, which are equal to the ILS Category I OAS surfaces

NOT FOR COMMERCIAL PURPOSES
**APV Segment**

**APV or Category I segment: Obstacle clearance**

**FPAP and GARP positioning:**

**FPAP (Flight path alignment point).** The FPAP is a point in the same lateral plane as the LTP or FTP that is used to define the alignment of the final approach segment. For approaches aligned with the runway centre line, the FPAP is located at or beyond the opposite threshold of the runway. The delta length offset from the opposite threshold of the runway defines its location.

**GARP (GBAS Azimuth Reference Point) is defined to be beyond the FPAP along the procedure centre line by a fixed offset of 305m (1000FT).** It’s used to established the lateral deviation display limits.

Two cases can be distinguished in the location of the FPAP (and so is the GARP):

a) there is no existing ILS for the approach; and

b) an ILS exists for the approach.

b’) LOC within 305m from the runway end

b”) ILS exists and LOC more than 305 m from the runway end
APV Segment

APV or Category I segment: Obstacle clearance

a) there is no existing ILS for the approach

FPAF is the Runway End and the GARP is 305 m beyond.

Figure III-2-6-1. FPAP location (no existing ILS for the approach)
**APV Segment**

**APV or Category I segment: Obstacle clearance**

b) existing ILS for the approach
   b’ ) LOC within 305m from the runway end

FPAF is the Runway End and if LOC is within 305m from it the GARP is still defined 305m beyond FPAF.
APV Segment

APV or Category I segment: Obstacle clearance

b) ILS exists for the approach
   b’’ ) LOC more than 305m from the runway end

The GARP becomes the LOC and the FPAP is located 305m backward. The distance between the FPAP and the Runway End is the delta length offset.

Figure III-2-6-3. FPAP location (ILS exists and LOC more than 305 m from the runway end)
APV Segment

APV or Category I segment: Obstacle clearance
Aircraft dimension (standard parameters)

5.1.2 Standard conditions

The following list contains the standard assumptions on which procedures are developed. Provisions are made for adjustments where appropriate. Adjustments are mandatory when conditions differ adversely from standard conditions and are optional when so specified.

a) maximum aircraft dimensions are assumed to be the following:

<table>
<thead>
<tr>
<th>Aircraft category</th>
<th>Wingspan</th>
<th>Vertical distance between the flight paths of the wheels and the centre of navigation (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>30</td>
<td>3</td>
</tr>
<tr>
<td>A, B</td>
<td>60</td>
<td>6</td>
</tr>
<tr>
<td>C, D</td>
<td>65</td>
<td>7</td>
</tr>
<tr>
<td>D_L</td>
<td>80</td>
<td>8</td>
</tr>
</tbody>
</table>

Note 1.— *OCA/H* for *D_L* aircraft are published when necessary.

Note 2.— The dimensions shown are those which encompass current aircraft types. They are chosen to facilitate *OCA/H* calculations and promulgation of aircraft category related minima. It is assumed that these dimensions are not intended to be used for other purposes than the *OCA/H* calculations in other ICAO documents.
**APV Segment**

**APV or Category I segment: Obstacle clearance**

The OAS surfaces are disposed symmetrically about the APV segment track and the horizontal plane containing the threshold. The geometry of the sloping surfaces is precisely defined by four simple linear equations of the form $z = Ax + By + C$. In these equations $x$ and $y$ are position coordinates and $z$ is the height of the surface at that position.

The SBAS Category I OAS contains the following sloping surfaces: W, X, Y and Z, which are equal to the ILS Category I OAS surfaces.

Y and Z surfaces are laterally limited by the area width of the RNAV APCH final segment.

The SBAS Category I OAS contains the following sloping surfaces: W, X, Y and Z, which are equal to the ILS Category I OAS surfaces.
APV Segment

APV or Category I segment: Obstacle clearance

For each surface the constants A, B and C are obtained from the PANS-OPS OAS software (see http://www.icao.int/safety/AirNavigation/OPS/Pages/PANS-OPS-OAS-Software.aspx) for the operational range of GARP/THR distances and GP. Separate sets of constants are provided for APV I, APV II or Category I.

The PANS-OPS OAS software gives coefficients for GP angles between 2.5 and 3.5 degrees in 0.1-degree steps, and for any GARP-threshold distance between 2 000 m and 4500 m.

Adjustment of SBAS OAS constants. Adjustments of SBAS OAS constants for specific aircraft dimensions and RDH different from 15 m are applied. Refer to Pans Ops Part II, Section 1, Chapter 1, 1.4.8.7, “Adjustment of OAS constants”.

For SBAS Category I OAS select CAT I ILS in approach category.

X, Y, Z axis origin is at the THR (FTP). The X axis aligned with the runway centre line. X values are positive before THR (in the direction of flight) and negative after THR. Y coordinate, since the surfaces are disposed symmetrically to the runway centre line, is always positive. Z is always positive. Refer to slide (frame of reference) for more info.
APV Segment

APV or Category I segment: Obstacle clearance

Determination of OCA/H

- Determine the obstacles that are penetrating the OAS set of surface applicable to the procedure.

- Determine which obstacle from the penetrating ones are those to be considered “Missed Approach Obstacle”

- Reduce the heights of all missed approach obstacles to the heights of equivalent approach obstacles

- Determine OCA/H by adding the appropriate Table II-1-1-2, “Height loss altimeter margin” aircraft category related margin to the height of the highest approach obstacle (real or equivalent).
APV Segment

APV or Category I segment: Obstacle clearance

Computing penetration

To determine which obstacles are penetrating the OAS:
• Defined which are the applicable OAS to be used (APV I, APV II, CAT I)

• Extract the applicable OAS Constants from OAS software

• Using the OAS equation calculate the height of the surfaces above the obstacles.

• The obstacle is penetrating if Z surface is less the Z obstacle
APV Segment

APV or Category I segment: Obstacle clearance

Frame of reference.
Positions of obstacles are related to a conventional x, y, z coordinate system with its origin at the threshold. The x axis is parallel to the precision segment track, positive x being measured before threshold and negative x being measured after threshold. The y-axis is at right angles to the x-axis. Although shown conventionally in Figure III-3-5-3, in all calculations associated with SBAS OAS geometry, the y coordinate is always counted as positive. All dimensions connected with the SBAS OAS are specified in metres only. The z-axis is vertical, heights above threshold being positive.
**APV Segment**

**APV or Category I segment: Obstacle clearance**

**Determination of missed approach obstacles**

The simplest method of partition is by range:
approach obstacles are those between the FAP and range XE after threshold, and missed
approach obstacles are those in the remainder of the APV segment (see Figure III-3-5-6).

![Diagram showing missed approach obstacle after range XE](image)

**Figure III-3-5-6.** Missed approach obstacle after range $-X_E$

However …… ( see next slide )
APV Segment

**APV or Category I segment: Obstacle clearance**

**Determination of missed approach obstacles**

However, in some cases it may produce an excessive penalty for certain missed approach obstacles. Where desired by the appropriate authority, missed approach obstacles may therefore be defined as those above a plane surface parallel to the plane of the GP and with origin at \(-XE\) (see Figure III-3-5-7), i.e. obstacle height greater than \((XE + x) \tan GP\).

![Diagram showing missed approach obstacle determination](image)

**Figure III-3-5-7.** Missed approach obstacle before range \(-XE\)
APV Segment

**APV or Category I segment: Obstacle clearance**

Reduce the heights of all missed approach obstacles to the heights of equivalent approach obstacles:

\[
h_a = \frac{h_{ma} \cdot \cot Z + (X - X_E)}{\cot Z + \cot \theta}
\]

where:
- \(h_a\) = height of equivalent approach obstacle
- \(h_{ma}\) = height of missed approach obstacle
- \(\theta\) = VPA
- \(Z\) = angle of missed approach surface
- \(X\) = range of obstacles relative to threshold (negative after threshold)
- \(X_E\) = 900 + (38/tan \(\theta\)) for APV I and \(X_E = 900 + (8/tan \(\theta\)) for APV II
- For Cat H, \(X_E = 700 + (38/tan \(\theta\)) for APV I and \(X_E = 700 + (8/tan \(\theta\)) for APV II.

\(X_e\) for definition is after THR so it is always negative.

\[
h_a = \frac{h_{ma} \cdot \cot Z + (X - (-X_E))}{\cot Z + \cot \theta}
\]

\[
h_a = \frac{h_{ma} \cdot \cot Z + (X_E + X)}{\cot Z + \cot \theta}
\]

In this formula \(X_e\) is an absolute value.

\(X\) is negative after THR indeed, since we are talking about MA obstacles, it is always negative.

**Note.—** For SBAS Category I operations, OCA/H calculations may use the ILS Category I OCA/H calculation.
APV Segment

APV or Category I segment: Obstacle clearance

Determine OCA/H

Once all penetrating obstacle have been identified and equivalent obstacle for those located in after XE have been computed:

• Take the higher obstacle between real approach obstacles and equivalent approach obstacles

• Add to the higher obstacle the aircraft related margin Height Loss altimeter Margin.
APV Segment

APV or Category I segment: Obstacle clearance

Height Loss Altimeter Margin

Height loss altimeter margin are the same as ILS procedure.

<table>
<thead>
<tr>
<th>Aircraft category ((V_{\text{so}}))</th>
<th>Margin using radio altimeter</th>
<th>Margin using pressure altimeter</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Metres</td>
<td>Feet</td>
</tr>
<tr>
<td>A – 169 km/h ((90 \text{ kt}))</td>
<td>12</td>
<td>42</td>
</tr>
<tr>
<td>B – 223 km/h ((120 \text{ kt}))</td>
<td>18</td>
<td>59</td>
</tr>
<tr>
<td>C – 260 km/h ((140 \text{ kt}))</td>
<td>22</td>
<td>74</td>
</tr>
<tr>
<td>D – 306 km/h ((165 \text{ kt}))</td>
<td>26</td>
<td>85</td>
</tr>
<tr>
<td>H – 167 km/h ((90 \text{ kt}))</td>
<td>8</td>
<td>26</td>
</tr>
</tbody>
</table>

Note 1.— Cat H speed is the maximum final approach speed, not \(V_{\text{so}}\).

Note 2.— For Category E aircraft refer directly to the equations given in 1.4.8.3.4.

Adjustment for high airfield elevations and steep glide path angles on Height loss \((HL)/altimeter margins\). The margins in Table II-1-1-2 shall be adjusted as follows in the next slide.
APV Segment

APV or Category I segment: Obstacle clearance

**Height Loss Altimeter Margin adjustments**

• for airfield elevations higher than 900 m (2 953 ft), the tabulated allowances shall be increased by 2 per cent of the radio altimeter margin per 300 m (984 ft) airfield elevation; and

• for glide path angles greater than 3.2°, in exceptional cases, the allowances shall be increased by 5 per cent of the radio altimeter margin per 0.1° increase in glide path angle between 3.2° and 3.5°.
APV Segment

**APV or Category I segment: Obstacle clearance**

### Height Loss Altimeter Margin adjustments

*For Steep glide path angle…*

Procedures involving glide paths greater than 3.5° or any angle when the nominal rate of descent (Vat for the aircraft type multiplied by the sine of the glide path angle) exceeds 5 m/s (1 000 ft/min) are non-standard for fixed-wing aircraft.

They require the following:

- increase of height loss margin (which may be aircraft-type specific);
- adjustment of the origin of the missed approach surface;
- adjustment of the slope of the SBAS APV OAS W and W’ surfaces or SBAS Category I OAS adjustment of the W surface;
- re-survey of obstacles; and
- the application of related operational constraints.

Such procedures are normally restricted to specifically approved operators and aircraft and are associated with appropriate aircraft and crew restrictions. For fixed-wing aircraft they are not to be used as a means to introduce noise abatement procedures.

The appendix to Chapter 5 shows the procedure design changes required for APV SBAS procedures for glide path angles up to 6.3° (11 per cent) and the related operational/certification considerations.
Part 4
Missed Approach Segment
Missed Approach

Missed Approach Segment: General

The criteria for the final missed approach are based on those for the general criteria (see Part I, Section 4, Chapter 6) with certain modifications to allow for the different areas and surfaces associated with the APV or Category I segment and the possible variation in OCA/H for that segment with aircraft category.
Missed Approach

**Missed Approach Segment : Start of Climb**

The datum used for calculation of distances and gradients in obstacle clearance calculations is termed “start of climb” (SOC). It is defined by the height and range at which the plane GP’ reaches an altitude OCA/H – HL (where OCA/H and HL both relate to the same category of aircraft).

\[ X_{soc} = X_e + \frac{(OCH - HL)}{\tan GP} \]

\( X_e \) is negative because after THR.

**Figure III-3-5-9.** Straight missed approach obstacle clearance

**NOT FOR COMMERCIAL PURPOSES**
Missed Approach

**Missed Approach Segment : Straight**

APV or Category I segment terminates at the range where the Z surface reaches a semi-width of 1.76 km (0.95 NM) (for helicopters 1.48 km (0.8 NM)). For the straight part of the final missed approach the area semi-width is equal to 1.76 km (0.95 NM) (for helicopters 1.48 km (0.8 NM)). Secondary areas are not applied.

![Diagram](image)

**Figure III-3-5-8.** Final segment of straight missed approach
Missed Approach

Missed Approach Segment : Straight Segment Obstacle Clearance

Obstacle elevation/height in this final missed approach area shall be less than

\[(OCA/H_{APV} - HL) + do \tan Z\]

where:

- \(OCA/H_{APV}\) and \(HL\) both relate to the same aircraft category.
- \(do\) is measured from SOC parallel to the straight missed approach track.
- \(Z\) is the angle of the missed approach surface with the horizontal plane.

If this criterion cannot be met, a turn shall be prescribed to avoid the offending obstacle, or if this proves impractical, the OCA/H shall be raised.

**Figure III-3-5-9. Straight missed approach obstacle clearance**
Missed Approach

Missed Approach Segment: Turning Missed Approach

Turn outside APV or Category I segment

If a turn is prescribed after the normal termination range of the APV or Category I segment, the general criteria of Part I, Section 4, Chapter 6, 6.4.6.4 apply with the following exceptions:

1) OCA/H is replaced by (OCA/HAPV – HL); and

2) because SOC is related to OCA/H, it is not possible to obtain obstacle clearance by the means used in the general criteria by independent adjustment of OCA/H or MAPt.
Missed Approach

Missed Approach Segment: Turning Missed Approach

Turn inside APV or Category I segment

If a turn is prescribed at a designated TP such that the earliest TP is within the normal termination range, depending on the following conditions different criteria shall be applied:

1) Turn at a designated TP after the threshold with earliest TP before normal termination of APV or Category I segment.

2) Turn at a designed TP before the threshold.
Missed Approach

Missed Approach Segment : Turning Missed Approach

**Turn inside APV or Category I segment**

"Turn at a designated TP after the threshold with earliest TP before normal termination of APV or Category I segment."

Where a turn is specified at a designated TP after the threshold, and the earliest TP is before the normal termination range of the APV or Category I segment, the APV or Category I segment is curtailed and terminates at the earliest TP. This allows the calculation of OCA/HAPV and (OCA/HAPV – HL); SOC is then determined.

![Diagram](image-url)
Missed Approach

*Missed Approach Segment : Turning Missed Approach*

**Turn inside APV or Category I segment**

“Turn at a designated TP after the threshold with earliest TP before normal termination of APV or Category I segment.”

The turn area is constructed as specified in Part I, Section 4, Chapter 6, 6.4.6, “Turn initiated at a designated turning point”, except that it is based on the width of the SBAS OAS Y surface contours at the earliest and latest TP.

---

**Note** — Obstacles located under the “Y” surface on the outer side of the turn (shaded area) need not be considered.
Missed Approach

**Missed Approach Segment : Turning Missed Approach**

Obstacle elevation/height shall be less than:

\[(OCA/H_{APV} - HL) + d_o \tan Z - MOC\]

where:

- \(d_o = dz + \) shortest distance from obstacle to line K-K'; and
- \(dz = \) horizontal distance from SOC to the earliest TP,
- \(MOC = 50 \text{ m (164 ft)} \) (Cat H, 40 m (132 ft)) for turns more than 15° and 30 m (98 ft) for turns 15° or less.

If the obstacle elevation/height exceeds the OCA/HAPV, the OCA/HAPV shall be increased, or the TP moved to obtain the required clearance.
Missed Approach

Missed Approach Segment : Turning Missed Approach

**Turn inside APV or Category I segment**

“Turn at a designated TP before the threshold”

A turn at a designated TP before the threshold may be prescribed to avoid obstacles located early in the straight missed approach. For such procedure the Final Approach Segment (FAS) data block shall be implemented using a Fictitious Threshold Point (FTP) located at the TP.
Missed Approach

Missed Approach Segment : Turning Missed Approach

Turn inside APV or Category I segment

“Turn at a designated TP before the threshold”

Turning point
A latest turning point is chosen to allow the aircraft to avoid obstacles straight ahead. Then the turning point (TP) is plotted before the latest TP at a distance equivalent 0.24 NM * plus 6 seconds of flight (pilot reaction and bank establishing time) at the final missed approach speed (or maximum published missed approach speed) plus 56 km/h (30 kt) tailwind. For this kind of turn the SOC is coincident with the earliest TP and the APV or category I segment terminates at this point. The OCA/HAPV is equal to the altitude/height of the SOC increased by the HL value.

* PANS OPS reports 0.3 NM in the text and 0.24 NM in Figure III-3-5-11. The correct values is 0.24 which is the ATT for Final and MA segment.
• Determine the latest TP (X latest) to exclude O1 from protection area.

• Determine X TP based on X X latest (shifted back by 0.24 NM + C tolerance)

• Determine X Earliest based on X TP (shifted back by 0.24 NM)

Once the Earliest TP has been established, the projection on GP' is the SOC altitude and it is easy then to find the OCA (SOC + HL).
Missed Approach

Missed Approach Segment: Turning Missed Approach

Turn inside APV or Category I segment

“Turn at a designated TP before the threshold”

The turn area is constructed as specified in Part I, Section 4, Chapter 6, except that it is based on the width of the SBAS OAS Y surface contours at the earliest and latest TP (see picture).

Note.—Obstacles located under the “y” surface on the outer side of the turn (shaded area) need not be considered.
Missed Approach

Missed Approach Segment : Turning Missed Approach

Turn inside APV or Category I segment

“Turn at a designated TP before the threshold”

Obstacle elevation/height shall be less than:

\[ (OCA/H_{APV} - HL) + d_o \tan Z - MOC \]

where:

\[ d_o = \text{shortest distance from obstacle to line K-K'} \]

and MOC is:

50 m (164 ft) (Cat H, 40 m (132 ft)) for turns more than 15° and 30 m (98 ft) for turns 15° or less.

Remark:

do = dz + shortest distance from obstacle to line K-K'; and

\[ dz = \text{horizontal distance from SOC to the earliest TP} \]

Error in PANS-OPS

NOT FOR COMMERCIAL PURPOSES
Part 5
SBAS Approach with OFFSET
Approach track alignment
SBAS Approach with OFFSET Approach track alignment

SBAS OFFSET : Generals

In certain cases it may not be physically practicable to align the final approach segment with the runway centre line because of obstacle problems. An offset final approach track shall not be established as a noise abatement measure. The final approach track shall intersect the runway extended centre line:

• at an angle not exceeding 5°; and
• at a point where the nominal glide path reaches a height called intercept height of at least 55 m (180 ft) above threshold.

The procedure shall be annotated: “final approach track offset ... degrees” (tenth of degrees).
SBAS Approach with OFFSET Approach track alignment

SBAS OFFSET : Obstacle Clearance

The provisions for APV segment apply except that:

• all the obstacle clearance surfaces and calculations are based on a fictitious runway aligned with the final approach track. This fictitious runway has the same length and the same landing threshold elevation as the real one. The FTP and the course width at the FTP are analogous to the LTP for an aligned procedure. The DCP is located 15 m (50 ft) above the FTP; and

• the OCA/H for this procedure shall be at least: intercept altitude/height + 20 m (66 ft).

• The general arrangement is shown in Figure III-3-6-18.
SBAS Approach with OFFSET Approach track alignment

![Diagram of SBAS Approach with OFFSET Approach track alignment](image)

Figure III-3-6-18. GBAS Cat I with offset azimuth final approach course alignment
Part 6
SBAS Non precision approach
SBAS Non Precision Approach

SBAS NPA : Final approach segment

The final approach segment areas are formed by using the outer lateral boundaries of the X surfaces beginning at threshold and extending until reaching a semi-width of 1 760 m (0.95 NM) and continuing at that semi-width at greater distances. This occurs at approximately 11.7 km (6.3 NM), depending on the distance from LTP to GARP. A secondary area is formed based on a primary width of 880 m (0.475 NM). The secondary area continues at this width toward the threshold until reaching the semi-width of the X surfaces. At this point the secondary area width diminishes to zero.
SBAS Non Precision Approach

SBAS NPA: Final approach segment semi-width surfaces

The semi-width of the final approach surfaces shall be determined using the following formulae:

\[
YLTP = [-0.0031 \times (GARP - LTP) + 182.83] \text{ metres and} \\
\theta_x = [-0.0006 \times (GARP - LTP) + 9.4367] \text{ degrees}
\]

where:

YLTP is the semi-width of the final approach surface at the LTP/FTP.

\(\theta_x\) is the angle of splay outward from the LTP/FTP of the final approach surface (see Figures III-3-5-11 and III-3-5-13).

\(W/2\) is computed as: \(YLTP + \text{ the distance from the LTP/FTP multiplied by } \tan \theta_x\).
SBAS Non Precision Approach

SBAS NPA: Final approach segment semi-width surfaces

Final Segment with MAPt at LTP

Figure III-3-5-12. Final approach segment with MAPt at LTP (LP)
SBAS Non Precision Approach

SBAS NPA: Final approach segment semi-width surfaces

Final Segment with MAPt prior to LTP

Figure III-3-5-13. Final approach segment with MAPt prior to LTP (LP)
SBAS Non Precision Approach

**SBAS NPA : Intermediate Segment**

The intermediate segment is joined to the final segment by constructing a line from the outer boundary of the intermediate segment to the outer boundary of the X surface at 30 degrees to the track and passing through the specified semi-width at the FAF/FAP.

See Part III, Section 3, Chapter 4 and Figure III-3-5-14.
Figure III-3-5-14. Intermediate segment connecting to final segment

\[
\begin{align*}
W/2(LTP) &= [-0.0031(\text{GARP-Threshold}) + 182.83] \, \text{M;}
\theta_x &= [-0.0006(\text{GARP-LTP}) + 9.4367] \, \text{degrees}
\end{align*}
\]

(LP and LPV). FAF/FAP closer to LTP than distance at which \(W/2 = 0.95 \, \text{NM}\)
SBAS Non Precision Approach

SBAS NPA : Missed Approach

The missed approach area shall start at the early ATT of the MAPt, with a splay of 15 degrees each side of the outer boundary of the final segment (X surface lateral boundaries). Secondary areas shall be applied when the expanded semi-width reaches the appropriate dimension for the RNP or RNAV navigation accuracies applied for missed approach guidance.

The obstacle evaluations and establishment of the OCA/H shall be carried out in the same manner as the LNAV criteria.
Part 7
Promulgation
Promulgation

Promulgation: Generals

The general criteria in Part I, Section 4, Chapter 9, 9.5, “Procedure naming for arrival and approach charts” apply. The instrument approach chart for an SBAS approach procedure shall be identified by the title RNAV(GNSS) or RNP Rwy XX in accordance with Part III, Section 5, Chapter 1.
Promulgation: OCA/H for SBAS approach procedures

The OCA/H values shall be promulgated for those categories of aircraft for which the procedure is designed. The values shall be based on the following standard conditions:

- approach flown with barometric altimeter;
- standard aircraft dimensions (see 6.1.3); and
- 2.5 per cent missed approach climb gradient.

Additional values of OCA/H may be agreed between operators and appropriate authority and promulgated, on the basis of evidence supporting the modifications defined in 5.4.5.7.
Promulgation

Promulgation: Minima BOX

- A table of OCA/H values for each aircraft category may be promulgated for SBAS operations at the particular aerodrome.

- All APV and Cat I SBAS OCA/H’s are promulgated as LPV lines of minima.

- All NPA OCA/Hs shall be promulgated as LP (localizer performance) lines of minima.

- LPV and LP lines of minima shall not be published on the same chart.
Promulgation

Promulgation: Additional gradient for the final missed approach segment.

If obstacles identified in the final missed approach segment result in an increase in any of the OCA/H calculated for the precision segment, an additional steeper gradient may also be specified for the gradient of the missed approach surface (Z) for the purpose of lowering the OCA/H.

(see Part I, Section 4, Chapter 6, 6.2, “Climb gradient and MOC”).
Promulgation

Promulgation: Final approach segment data block (FAS Data Block)

The FAS DB is specified in Part III, Section 3, Chapter 6. It shall be promulgated in a textual format on the verso of the approach chart or a separate sheet, and shall contain at least the data indicated in Table III-3-5-1.

How to compute and generate the FAS DATA BLOCK will be explained in the next training session.

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Grazie