Flight Procedure Design Software Validation

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Vadim Tumarkin, LGS, Latvia
Jabir Jumshudov, R.I.S.K. Company, Azerbaijan
Definition

• **Validation** is an acknowledgement that the standards derived from a series of tests have been complied with, and does not imply any certificate delivery.

• A procedure design tool validation means that compliance with standards is recognized for most significant cases of the tool use.

• A validation assumes the existence of applicable standards and a given methodology (guidance and pre-defined tests).

• Validation may occur after development, using “off-the-shelf” products.
The need for validation of procedure design tools

• Although procedure design tools are increasingly available to designers and can save significant time when creating designs, as well as improve compliance with collaborative work, they can be misleading if
  – they contain errors, or
  – if procedure design criteria compliance is not ensured through all the functions provided by such tools.

• Thus, there is a significant need to define a validation process for procedure design tools.

• Additionally, the validation is a means for users to gain confidence in a tool.

• It is recommended that both the procedure design organization using a tool and the procedure design software developer/provider be involved in its validation.

• For this reasons the special R.I.S.K. company/LGS team was established to be involved in its validation.
Validation with regard to criteria

- Validation with regard to criteria consists of a compliance verification of the results obtained in a series of tests of the tool using applicable criteria.
- The applied tests cover all the relevant functions of the tool (including general functions and some input/output functions).
- These tests include the comparison between the results obtained with the tool and the ones obtained manually or presented in ICAO Doc 8168 Volume II.
- Validation tests are carried out according to a predefined list and guidance.
CAA request for FPD SW validation

Before ILS CAT II procedures publication in AIP the Validation of the FPD SW is needed as specified in the national regulations № 1112/2013
LGS report about FPD SW validation

FPD SW validation for ILS CAT II procedures has been completed successfully

Par PANDA sistēmas validācijas izpildi.


Validācijas rezultātus plānots prezentēt ICAO un EUROCONTROL, ņemot vērā starptautisko interesi par Latvijas pieredzi šajā sfērā.

Ar cieņu,
valdes priekšsēdētājs

D. Tauriņš

PBN/PANS-OPS Workshop, Minsk 2015 6
PANDA SW validation basis

• The PANDA SW validation is based on the criteria defined by ICAO, especially those contained in the Procedures for Air Navigation — Aircraft Operations (PANS-OPS, Doc 8168).

• The following latest ICAO provisions were used during the PANDA SW validation process:


  • There is a special agreement between R.I.S.K. Company and LGS for SW updating to ensure ICAO flight procedure criteria actuality.
Validation building

Methodology, environment and documentation
Preparation

• Before to start PANDA SW validation the following preliminary activities were organized and made.

• A work plan was develop to define:
  – the software validation coverage taking into account CAA letter 9.10.2014 Nr. 01- 8-1/1076.
  – the overall objective schedule;
  – the available resources;
  – the validation team for the validation process
  – the tasks to be carried out;
  – the roles and responsibilities of each team member for each task; and
  – a tentative detailed work programme (work items and timeframe).
Methodology implemented

• The validation implementation includes a series of tests to be carried out according to the validation coverage.

• Prior to any validation task, it was confirmed by the procedure design software developer (R.I.S.K. Company) that hardware and software are installed and configured according to the hardware and software specifications.

• The PANDA SW testing was followed a predefined written plan with a formal summary of testing and a record of formal acceptance and covers the full range of ILS approach CAT II operating conditions.

• PANDA SW tests have been carried out at the system developer’s location (R.I.S.K. Company premises) and user location (LGS premises).

• User site testing was accomplished in the actual working environment that was a part of the installed system configuration.

• Knowledge of test planning, definition of expected test results, and recording of all test outputs was provided for all parties involved with the support from the procedure design software developer.
Validation documentation

• During the validation implementation, detailed documentation of the tests being carried out was compiled.

• A comparison with the applicable criteria was organized to demonstrate that there is no discrepancy between these criteria and the tool documentation.

• The PANDA documentation provided conforms to the predefined functionalities and follows from the technical reference criteria and material.

• This documentation includes the history of the tests, including input data and test results as specified in Appendix E of ICAO Doc 9906 Volume 3.

• For the purpose of continuous improvement of the software, the validation documentation is available to the procedure design software developer.
Aeronautical data integration and updates

• The validation of aeronautical data integration was made to verify the correctness of
  the integration of data elements (and associated attributes) from the originating
  database to the PANDA itself.
• The data considered for integration into procedure design tools include all the data
  that used during the process of procedure design, such as:
  – navaisds — attributes include type, coordinates, and (if used by the tool) declared
    operational coverage;
  – landing aids — attributes include type and elements (e.g. localizer, glide,
    distance measuring equipment (DME), etc.) with their respective coordinates, and,
    if used by the tool, additional attributes (category, angle, etc.);
  – aerodromes — attributes include name and/or location indicator, aerodrome
  – reference point (ARP) coordinates, aerodrome elevation, and runway indicators;
  – runway features — thresholds, ends, etc., with their respective coordinates;
  – obstacles — attributes include coordinates, elevation, height (where applicable);
  – airspace features — boundaries of restricted areas, control zone, terminal area,
  – flight information region, etc., and relevant attributes (e.g. geometry descriptors);
  – waypoints, intersections, fixes, reporting points — attributes include name, type
    and coordinates.
Metadata assessment

• In order to ensure that the data are correctly integrated in the PANDA system, the metadata (data about the concerned set of data) associated to the database were accessed also.

• Metadata include the following items:
  – data source;
  – horizontal reference system (e.g. WGS-84);
  – vertical reference (e.g. mean sea level); and
  – units.

• The validation of the data integration was carried out through integration of a representative set of the initial data into the PANDA system, and comparison between the PANDA system data set and the initial data set.
PANDA main functions and Input/output possibilities
Validation of basic data and parameters

- The list of the raw data and parameters used for calculations during the precision approach flight procedure design was created and assessed.

- In order to facilitate the basic element validation the appropriate guidance material of ICAO Doc 9906 Volume 3 (Appendix D) was used about the reference criteria, values and formulas corresponding to ILS approach procedure design basic functions.

- The modelling of criteria validation used by PANDA system is based on the comparison of results achieved using the tool with results obtained through manual implementation of the criteria (drawings and calculation results, etc.) for realistic examples (ILS approach at AD Riga).

- The differences between these results were identified and analysed, so that they can be either accepted or rejected, on the basis of advice from procedure design experts.
Application of criteria modelling validation

The following four validation domains were established:

Domain 1 — Methods or concepts used by the software tool

Domain 2 — Input data

Domain 3 — Output values

Domain 4 — Graphical check

with the four possible (and exclusive) levels of assessment:

– yes = the element/topic is acceptable;
– no = the element/topic is not acceptable;
– unknown = the element/topic cannot be assessed;
– out of coverage = the element/topic is not included in the validation coverage.
Flight Procedure Design Software Validation Results
Domain 1 — Methods or concepts used by the software tool

• During the validation team investigated how the software interprets and utilizes the regulation criteria associated to the appropriate element and appropriate decisions were made for the assessed elements by means of acceptance “yes/no”.

• Independent calculations using SMath Studio were done for the following basic elements (Attachment 1):
  – Altimeter margins;
  – Determining ILS Glide Path Descent Elevation/height and Distance;
  – Fixes construction;
  – Basic ILS surfaces;
  – Specific aircraft dimensions;
  – OCA/H calculation;
  – IAS to TAS calculation;
  – Turn Altitude/Height calculation;
Domain 2 — Input data

• For the “Input data” validation domain the following was assessed: Are the proposed values for a given item applicable with respect to usage?

• During the validation it was identified that:
  – PANDA SW being the expert tool before to start the appropriate procedure design retrieves the appropriate data from LGS Integrated AIM DB and checks the data completeness needed;
  – All the data stored in IAIM DB presented in the AIXM 5.1 format and they are transparent for independent review and analysis.
  – PANDA system uses proposed locked values for PANS-OPS constants and these values cannot be entered into Flight procedure design environment if they are outside the predefined limits;
  – PANDA system uses managed input fields, i.e. input data submitted to consistency/plausibility checks; and/or
  – unmanaged input fields if the data is retrieved from IAIM DB or the data is unchangeable parameter.
Domain 3 — Output values

- For the “output data” validation domain the following was assessed:
  - Is the output applicable with respect to the input?
  - Or is it not available (and de facto it cannot be assessed)?
- During the validation it was identified that:
- Being the expert tool PANDA system creates output in form of “Procedure transitions” entering appropriate AIXM 5.1 feature classes by information/data constructed during the flight procedure design.
- All the data being as flight procedure design output are presented in the AIXM 5.1 format, stored in IAIM DB and they are transparent for independent review and analysis.
Domain 4 — Graphical check

- For the “Graphical check” validation domain the following was assessed – (Attachment 3)
  - THR-FAF distance;
  - FAF tolerance area;
  - Basic ILS Approach surfaces;
  - OAS Cat I;
  - OAS Cat II;
  - Obstacle Free Zone (OFZ);
  - Obstacle data set integration into walls to be correctly used by Collision Risk Model;
Attachment 1. Independent calculations using SMath Studio

• Altimeter margins;
• Determining ILS Glide Path Descent Elevation/height and Distance;
• Fixes construction;
• Basic ILS surfaces;
• Specific aircraft dimensions;
• OCA/H calculation;
• IAS to TAS calculation;
• Turn Altitude/Height calculation;
## Altimeter margins

### Table I-4-1-1. Speeds (IAS) for procedure calculations in kilometres per hour (km/h)

<table>
<thead>
<tr>
<th>Aircraft category</th>
<th>$V_{at}$</th>
<th>Range of speeds for initial approach</th>
<th>Range of final approach speeds</th>
<th>Max speeds for visual manoeuvring (circling)</th>
<th>Max speeds for missed approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>&lt;169</td>
<td>165/280(205*)</td>
<td>130/185</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>169/223</td>
<td>220/335(260*)</td>
<td>155/240</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>224/260</td>
<td>295/445</td>
<td>215/295</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>261/306</td>
<td>345/465</td>
<td>240/345</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>307/390</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H</td>
<td>N/A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cat H (PinS)***</td>
<td>N/A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1.4.8.6.3.4 Height loss (HL)/altimeter margin is required for a specific $V_{at}$, the following is added:

### Use of radio altimeter:

Margin = (0.096 $V_{at}$ - 3.2) metres where $V_{at}$ in km/h

Margin = (0.177 $V_{at}$ - 3.2) metres where $V_{at}$ in kt

### Use of pressure altimeter:

Margin = (0.068 $V_{at}$ + 28.3) metres where $V_{at}$ in km/h

Margin = (0.125 $V_{at}$ + 28.3) metres where $V_{at}$ in kt

where $V_{at}$ is the speed at threshold based on 1.3 times stall speed in the landing configuration at maximum certificated landing mass.
Determining ILS Glide Path Descent Elevation/height and Distance

1. ILS/MLS glide path heights (H) and horizontal distances (D) from the threshold are calculated by solving a right-angle triangle:

**SI units**

\[ H = h + 1000 \, D \tan \theta \quad \text{and} \quad D = 0.001(H - h) \cot \theta \]

where:
- \( H \) = height in metres
- \( h \) = reference datum height in metres
- \( D \) = distance from the threshold in kilometres
- \( \theta \) = glide path angle in degrees

\[ H = 737.642144 \quad \text{and} \quad D = 13.7551744 \]

**Non-SI units**

\[ H = h + 6076 \, D \tan \theta \quad \text{and} \quad D = 0.0001646(H - h) \cot \theta \]

where:
- \( H \) = height in feet
- \( h \) = reference datum height in feet
- \( D \) = distance from the threshold in nautical miles
- \( \theta \) = glide path angle in degrees

\[ H = 2469 \, \text{ft} \quad \text{and} \quad D = 7.4272 \]

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The influence of the curvature of the earth’s surface

2. The influence of the curvature of the earth’s surface should be considered in order to check that the heights and distances to the threshold determined in this manner meet the Annex 10 and PANS-OPS requirements. To perform such a check, Tables II-1-1-App C-1 and II-1-1-App C-2 may be used. For intermediate distances, heights and glide path angles, the linear interpolation method is used.

For reference datum heights (h) other than 15 m (49 ft):

a) the values obtained from Table II-1-1-App C-1 should be corrected by adding \( \Delta H \) where:

\[
\begin{align*}
\text{SI units:} & \quad \Delta H = h - 15 & \quad (\text{Table II-1-1-App C-1a}) \\
\text{Non-SI units:} & \quad \Delta H = h - 49 & \quad (\text{Table II-1-1-App C-1b})
\end{align*}
\]

\[
\begin{align*}
h = 1 & \quad \delta H = h - 15 \\
h = 1 & \quad \delta H = h - 49
\end{align*}
\]

b) the values obtained from Table II-1-1-App C-2 should be corrected by adding \( \Delta D \) where:

\[
\begin{align*}
\text{SI units:} & \quad \Delta D = 0.00092(15 - h) \cot \theta & \quad (\text{Table II-1-1-App C-2a}) \\
\text{Non-SI units:} & \quad \Delta D = 0.0001514(49 - h) \cot \theta & \quad (\text{Table II-1-1-App C-2b})
\end{align*}
\]

\[
\begin{align*}
\delta D = 0.00092 \left(15 - h\right) \cot \theta & \quad \theta \cdot \frac{\pi}{180} = 0.245765 \\
\delta D = 0.0001514 \left(49 - h\right) \cot \theta & \quad \theta \cdot \frac{\pi}{180} = 0.138666
\end{align*}
\]
The following formulae may be used for intermediate distances, heights and glide path angles as well as for values which are greater than the maximum values indicated in Tables II-1-1-App C-1 and II-1-1-App C-2:

**SI units:**  \( H = h + 1\,000 \, D \tan \theta + 0.0785 \, D^2 \)

<table>
<thead>
<tr>
<th>h</th>
<th>m</th>
<th>D</th>
<th>km</th>
<th>θ</th>
</tr>
</thead>
<tbody>
<tr>
<td>16.764</td>
<td></td>
<td>13.7551744</td>
<td></td>
<td>3</td>
</tr>
</tbody>
</table>

\[
H = h + 1000 \cdot D \cdot \tan \left( \theta \cdot \frac{\pi}{180} \right) + 0.0785 \cdot D^2 = 752.494723
\]

and

**Non-SI units:**  \( H = h + 6\,076 \, D \tan \theta + 0.8833 \, D^2 \)

---

**Reference datum height** (for \( h = 55 \) ft)

**FAP-THR distance** \( D = 7.4272 \) nm

**Glide path angle** \( \theta = 3^\circ \)

\[
H = h + 6076 \cdot D \cdot \tan \left( \theta \cdot \frac{\pi}{180} \right) + 0.8833 \cdot D^2 = 2468.766565 \text{ ft}
\]

\[
-1000 \cdot \tan \left( \theta \cdot \frac{\pi}{180} \right) + \left( 10 \cdot 6 \cdot \tan \left( \theta \cdot \frac{\pi}{180} \right) \right)^2 + 0.314 \cdot (H-h) \cdot 0.3048 \right) \frac{0.5}{0.157}
\]

**FAP_THR_distance** = 13.755 km
## Fixes construction

<table>
<thead>
<tr>
<th>Navaid type</th>
<th>Splay angle for the protection area construction</th>
<th>Tracking</th>
<th>Intersecting</th>
</tr>
</thead>
<tbody>
<tr>
<td>VOR</td>
<td>7.8°</td>
<td>5.2°</td>
<td>4.5°</td>
</tr>
<tr>
<td>NDB</td>
<td>10.3°</td>
<td>6.9°</td>
<td>6.2°</td>
</tr>
<tr>
<td>LOC</td>
<td>NA</td>
<td>2.4°</td>
<td></td>
</tr>
<tr>
<td>DME</td>
<td>NA</td>
<td>0.46 km (0.29 mi)</td>
<td></td>
</tr>
</tbody>
</table>

### Definitions

- **D** distance from the reference facility to the facility
- **FTT** flight technical tolerance
- **ST** system computation tolerance
- **VT** \( D1 - D \cos(Q + \alpha) \)
- **DT** \( DTT \cos Q \)
- **AVT** \( D2 - D \sin(Q - \alpha) \)
- **ADT** \( DTT \sin Q \)
- **TSE** Total system error

### Equations

- \( D = \left( \frac{D1}{2} + \frac{D2}{2} \right)^2 = 10.7703 \)
- \( V_T = D1 - D \cos \left( \frac{Q + \alpha}{180} \right) \approx 3.6158 \)
- \( D_T = DTT \cdot \cos \left( \frac{Q \cdot \pi}{180} \right) = 1 \)
- \( A_V = D2 - D \sin \left( \frac{Q - \alpha}{180} \right) \approx 17.6158 \)
- \( A_D = DTT \cdot \sin \left( \frac{Q \cdot \pi}{180} \right) = 0 \)
- **TSE** - Total system error \( TSE = 0 \)

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Basic ILS surfaces

All x, y and z are in the same units

\[ z_1 = 0.00355 \cdot x_1 + 0.143 \cdot y_1 - 36.66 = -36.66 \]

\[ z_2 = -0.00145 \cdot x_2 + 0.143 \cdot y_2 - 21.36 = -21.21845 \]

\[ z_3 = 0.143 \cdot y_3 - 21.45 = -21.307 \]

\[ z_4 = 0.01075 \cdot x_4 + 0.143 \cdot y_4 + 7.58 = 7.73375 \]

\[ z_5 = -0.025 \cdot x_5 - 22.5 = -22.525 \]

\[ z_6 = 0.02 \cdot x_6 - 1.2 = -1.18 \]

\[ z_7 = 0.025 \cdot x_7 - 16.5 = -16.475 \]
Specific aircraft dimensions

1.4.8.7.3 *Specific aircraft dimensions.* An adjustment is mandatory where aircraft dimensions exceed those specified in 1.1.3, “Standard conditions” and is optional for aircraft with smaller dimensions. The PANS-OPS OAS software adjusts the OAS coefficients and template coordinates for the standard dimensions of Category A, B, C, D and D₁ aircraft automatically. It will do the same for specific aircraft dimensions in any category. It uses the following correction formula to adjust the coefficient C for the W, W*, X and Y surfaces:

- **W surface:** \[ C_{w, \text{corr}} = C_w - (t - 6) \]
- **W* surface:** \[ C_{w*, \text{corr}} = C_{w*} - (t - 6) \]
- **X surface:** \[ C_{x, \text{corr}} = C_x - B_x \cdot P \]
- **Y surface:** \[ C_{y, \text{corr}} = C_y - B_y \cdot P \]

where: \[ P = \left[ \frac{t}{B_2} \right. \text{or} \left. S + \frac{t^3}{B_2} \right], \text{whichever is the maximum} \] \[ - \left[ \frac{6}{B_x} \text{or} \frac{30 + 3}{B_x}, \text{whichever is the maximum} \right] \]

and \( s \) = semi-span

\( t \) = vertical distance between paths of the GP antenna and the lowest part of the wheels.

1.4.8.7.4 *Height of the ILS reference datum (RDH).* This is based on a reference datum height (RDH) of 15 m. An adjustment to the OAS constants is mandatory for an RDH less than 15 m, and is optional for an RDH greater than 15 m. The PANS-OPS OAS software adjusts the OAS coefficients and template coordinates by correcting the tabulated values of the coefficient C for the W, W*, X and Y surfaces as follows:

\[ C_{\text{corr}} = C + (RDH - 15) \]

where: \( C_{\text{corr}} \) = corrected value of coefficient C for the appropriate surface

\( C \) = tabulated value.
Specific aircraft dimensions

\[ t = 1 \quad Cw = 1 \quad Cw_{\text{ast}} = 1 \]
\[ Cx = 1 \quad Bx = 1 \quad Cy = 1 \quad By = 1 \quad S = 1 \]

\[ P1 = \text{if} \quad \frac{t}{Bx} > S + \frac{t - 3}{Bx} \]
\[ P2 = \text{if} \quad \frac{6}{Bx} \rightarrow 30 + \frac{3}{Bx} \quad \text{then} \quad \frac{6}{Bx} \]
\[ P = P1 - P2 = -32 \]

\[ W \text{ surface} \quad Cw_{\text{corr}} = Cw - \{t - 6\} - 6 \]
\[ W^{*} \text{ surface} \quad Cw_{\text{ast,corr}} = Cw_{\text{ast}} - \{t - 6\} - 6 \]
\[ X \text{ surface} \quad Cx_{\text{corr}} = Cx - Bx \cdot P = 33 \]
\[ Y \text{ surface} \quad Cy_{\text{corr}} = Cy - By \cdot P = 33 \]

\[ C = 1 \quad RDH = 1 \]
\[ C_{\text{corr}} = C + \{RDH - 15\} - 13 \]

\[ A = 0.0358 \quad B = 0 \quad C = -5.43 \]
\[ x = 152 \quad y = 68 \]
\[ z = A \cdot x + B \cdot y + C = 0.0116 \]

\[ Wz = 0.0358 \cdot x - 5.43 = 0.0116 \]
\[ W_{\text{az}} = 0 \cdot x - 0 = 0 \]
\[ Xz = 0.035818 \cdot x + 0.238265 \cdot y - 21.75 = -0.1036 \]
\[ Yz = 0.032536 \cdot x + 0.28539 \cdot y - 29.37 = -5.018008 \]
\[ Zz = 0.025 \cdot x - 22.5 = -26.3 \]

\[
M1 = \begin{bmatrix}
0.0358 & 0 & -5.43 \\
0.035818 & 0.238265 & -21.75 \\
0.032536 & 0.28539 & -29.37 \\
-0.025 & 0 & -22.5 \\
\end{bmatrix}
\]

\[
P_{\text{xy}} = \begin{bmatrix}
152 & 68 \\
-320 & 139 \\
-900 & 206 \\
-6900 & 1415 \\
\end{bmatrix}
\]

\[
F''_{\text{xy}} = \begin{bmatrix}
4342 & 68 \\
2542 & 339 \\
-6900 & 1415 \\
\end{bmatrix}
\]

\[ X = \begin{bmatrix}
152 & -320 & -900 & 0 & 4342 & 2542 & -6900 \\
68 & 139 & 206 & 0 & 68 & 339 & 1415 \\
\end{bmatrix}
\]

\[ Y = \begin{bmatrix}
68 & 139 & 206 & 0 & 68 & 339 & 1415 \\
\end{bmatrix}
\]

\[ Z = \begin{bmatrix}
0 & 0 & 0 & 1 & 150 & 150 & 150 \\
\end{bmatrix}
\]

\[ \text{THR Height} = 150 \]

\[
P_{\text{result}} = \begin{bmatrix}
Ml_1 \cdot P_{\text{xy}} & Ml_1 + Ml_3 & Ml_1 \cdot P_{\text{xy}} & Ml_1 + Ml_3 & Ml_1 \cdot P_{\text{xy}} & Ml_1 + Ml_3 & Ml_1 \cdot P_{\text{xy}} & Ml_1 + Ml_3 & Ml_1 \cdot P_{\text{xy}} & Ml_1 + Ml_3 \\
Ml_2 \cdot P_{\text{xy}} & Ml_2 + Ml_3 & Ml_2 \cdot P_{\text{xy}} & Ml_2 + Ml_3 & Ml_2 \cdot P_{\text{xy}} & Ml_2 + Ml_3 & Ml_2 \cdot P_{\text{xy}} & Ml_2 + Ml_3 & Ml_2 \cdot P_{\text{xy}} & Ml_2 + Ml_3 \\
Ml_3 \cdot P_{\text{xy}} & Ml_3 + Ml_3 & Ml_3 \cdot P_{\text{xy}} & Ml_3 + Ml_3 & Ml_3 \cdot P_{\text{xy}} & Ml_3 + Ml_3 & Ml_3 \cdot P_{\text{xy}} & Ml_3 + Ml_3 & Ml_3 \cdot P_{\text{xy}} & Ml_3 + Ml_3 \\
\end{bmatrix}
\]

\[
= \begin{bmatrix}
0.0116 & 150.0136 \\
-0.092925 & 150.071191 \\
-0.11231 & 150.083722 \\
\end{bmatrix}
\]
### 1.4.8.8.2.1 OCA/H Calculation steps

a) Determine the height of the highest approach obstacle.

b) Convert the heights of all missed approach obstacles ($h_{ma}$) to the heights of equivalent approach obstacles ($h_a$) by the formula given below, and determine the highest equivalent approach obstacle.

c) Determine which of the obstacles identified in steps a) and b) is the highest. This is the controlling obstacle.

d) Add the appropriate aircraft category related margin (Table II-1-1-2) to the height of the controlling obstacle.

\[
h_a = \frac{h_{ma} \cot Z + (x_z + x)}{\cot Z + \cot \theta}
\]

* where:  
  \( h_a \) = height of equivalent approach obstacle  
  \( h_{ma} \) = height of missed approach obstacle  
  \( \theta \) = angle of glide path (elevation angle)  
  \( Z \) = angle of missed approach surface  
  \( x \) = range of obstacle relative to threshold (negative after threshold)  
  \( x_z \) = distance from threshold to origin of \( Z \) surface (900 m (700 m Cat H))

\[
h_a = \frac{30.48 \cdot \cot \left( \frac{1.432 \cdot \pi}{180} \right) + (900 + 1342.3)}{\cot \left( \frac{1.432 \cdot \pi}{180} \right) + \cot \left( \frac{3 \cdot \pi}{180} \right)} = 13.150502 \text{ m}
\]

Altitude Margin: \( Alt = 22 \text{ m} \)

\[ h_{ft} = h_a \cdot 3.28 \cdot 43.133645 \text{ ft} \]

\[ OCA/H = h_a + \text{Altitude Margin} \quad \text{Alt}_{ft} = 71 \text{ ft} \]

\[ OCA_H = h_a + \text{Alt} = 35.150502 \text{ m} \]

\[ OCA_H_{ft} = h_{ft} + \text{Alt}_{ft} = 114 \text{ ft} \]
The following formula is used for values not listed in the table:

\[
\text{TAS} = \text{IAS} \times 171233 \left[ (288 \pm \text{VAR}) - 0.006496 \text{H} \right]^{0.5} \div (288 - 0.006496 \text{H})^{2.628}
\]

where: \( \text{VAR} = \) Temperature variation about ISA in °C, \( \text{H} = \) Altitude in metres.

For \( \text{IAS} = 160 \), \( \text{VAR} = 1.0411 \), and \( \text{H} = 1000 \):

\[
\text{TAS} = \frac{160 \times 171233 \left[ (288 + 1.0411) - 0.006496 \times 1000 \right]^{0.5}}{(288 - 0.006496 \times 1000)^{2.628}} = 168.2697
\]

\[
= \frac{160 \times 171233 \left[ (288 - 1.0411) - 0.006496 \times 1000 \right]^{0.5}}{(288 - 0.006496 \times 1000)^{2.628}} = 167.6485
\]
1.5.3.2.2  *Turn altitude/height*

The general criteria apply, modified as follows. The precision segment terminates (and the final missed approach segment begins) at the TP. This allows the calculation of OCA/H<sub>ps</sub> and (OCA/H<sub>ps</sub> – HL). SOC is then determined, and turn altitude/height (TNA/H) is computed from the following relationship:

\[
TNA/H = OCA/H_{ps} - HL + d_z \tan Z
\]

where:  
\(d_z\) is the horizontal distance from SOC to the TP and

\(OCA/H_{ps} = OCA/H\) calculated for the precision segment.

If the TP is located at the SOC, the chart shall be annotated “turn as soon as practicable to ... (heading or facility)” and shall include sufficient information to identify the position and height of the obstacles dictating the turn requirement.

<table>
<thead>
<tr>
<th>OCA_H&lt;sub&gt;ps&lt;/sub&gt;</th>
<th>114  Ft</th>
</tr>
</thead>
<tbody>
<tr>
<td>HL</td>
<td>71     Ft (altimeter margin)</td>
</tr>
<tr>
<td>THR_TPdist</td>
<td>4370</td>
</tr>
<tr>
<td>SOCdistFromTHR</td>
<td>651</td>
</tr>
<tr>
<td>(d_z = \left( THR_TPdist - SOCdistFromTHR \right) )</td>
<td>3.2808399 = 12201.443588</td>
</tr>
<tr>
<td>Z</td>
<td>1.432  (2.5%) missed approach procedure gradient</td>
</tr>
<tr>
<td>TNA_H</td>
<td>OCA_H&lt;sub&gt;ps&lt;/sub&gt; - HL + (d_z \tan \left( \frac{\Pi}{180} \right) ) = 348 Ft</td>
</tr>
</tbody>
</table>
Attachment 2. AIM Environment data integrity validation

- AIM Environment data integrity validation results are presented for the following data:
  - Area 2 obstacle data set
  - Airport data
  - Navigation aids
  - WGS-84 calculations
Obstacle data set validation

1. VALIDATION OF EVRA AREA 2 OBSTACLE DATA SET
   1.1. Test dataset: *VerticalStructure*
   1.2. Reference dataset: Data originator ESRI dataset
       *(RIX_Obstacles_WGS_21_07_2014.mdb)*
   1.3. Test environment: *IAIM Environment v.1.3*
   1.4. Test sequence:

<table>
<thead>
<tr>
<th>№</th>
<th>Operation</th>
<th>Result</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
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<td>Passed</td>
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</tr>
<tr>
<td>3.</td>
<td>Comparision of completeness of data geometry</td>
<td>Passed</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Comparision of completeness of attribute information</td>
<td>Passed</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Comparision of geometric accuracy</td>
<td>Passed</td>
<td>Test object: rix53_100 (antenna)</td>
</tr>
</tbody>
</table>
1.4.1. Test object **rix53_100** geometric accuracy control:

<table>
<thead>
<tr>
<th>Dataset</th>
<th>X (decimal degrees)</th>
<th>Y (decimal degrees)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VerticalStructure</td>
<td>56.932360</td>
<td>023.968750</td>
</tr>
<tr>
<td>RIX_Obstacle_point</td>
<td>56.93236001</td>
<td>23.9687499</td>
</tr>
</tbody>
</table>
2. VALIDATION OF POINT OBJECT INTEGRITY

2.1. Test dataset: *AirportHeliport*

2.2. Reference dataset: eAIP (text publication, map *EVRA AD 2.24.1 – 1*)

2.3. Test environment: *IAIM Environment v.1.3, ArcMap 10.2.2*

2.4. Test sequence:

<table>
<thead>
<tr>
<th>No</th>
<th>Operation</th>
<th>Result</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>IAIM data <em>AirportHeliport</em> uploading</td>
<td>Passed</td>
<td></td>
</tr>
</tbody>
</table>
| 2  | Reference vector dataset creation             | Passed | Object created in ArcMap 10.2.2 from AIP Part 3:
|    |                                               |        | *EVRA AD 2.2 AERODROME GEOGRAPHICAL AND ADMINISTRATIVE DATA* |
|    |                                               |        | ![ARP coordinates and site at AD](image) |
| 3  | Reference vector data uploading               | Passed |        |
| 4  | Reference raster data uploading               | Passed | Georeferenced map *EVRA AD 2.24.1 – 1* |
| 5  | Comparison of completeness of data geometry   | Passed |        |
| 6  | Comparison of completeness of attribute       | Passed |        |
|    | information                                    |        |        |
| 7  | Comparison of geometric accuracy              | Passed |        |
2.4.1. Test object geometric accuracy control:

<table>
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<th>Y (decimal degrees)</th>
</tr>
</thead>
<tbody>
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<td>AirportHeliport</td>
<td>56.923611</td>
<td>023.971111</td>
</tr>
<tr>
<td>Test data</td>
<td>56.923611</td>
<td>23.971111</td>
</tr>
</tbody>
</table>
3. VALIDATION OF NAVAID OBJECT INTEGRITY

3.1. Test dataset: *Navaid/VOR*

3.2. Reference dataset: eAIP (text publication)

3.3. Test environment: *IAIM Environment v.1.3, ArcMap 10.2.2*

3.4. Test sequence:

<table>
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<th>Operation</th>
<th>Result</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
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<td></td>
</tr>
<tr>
<td>2.</td>
<td>Reference vector dataset creation</td>
<td>Passed</td>
<td>Object created in ArcMap 10.2.2 from AIP Part 2: ENR 4.1 RADIO NAVIGATION AIDS EN-ROUTE</td>
</tr>
<tr>
<td>3.</td>
<td>Reference vector data uploading</td>
<td>Passed</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Comparision of completeness of data geometry</td>
<td>Passed</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Comparision of completeness of attribute information</td>
<td>Passed</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Camparision of geometric accuracy</td>
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<td></td>
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3.4.1. Test object geometric accuracy control:

<table>
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</thead>
<tbody>
<tr>
<td>AirportHeliport</td>
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<td>023.965194</td>
</tr>
<tr>
<td>Test data</td>
<td>56.920861</td>
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</tr>
</tbody>
</table>
Geographical information validation

- According to ICAO, all the coordinates used for air navigation must be expressed in the World Geodetic System of WGS-84 (for more information, refer to ICAO’s *World Geodetic System — 1984 (WGS-84) Manual* (Doc 9674)).

- The validation of geographical information was done to verify that the geographical data are correctly processed in the PANDA SW and to confirm that the parameters of geodetic reference systems and geographical projections used for flight procedure design fully comply with reference geographical standards.

- The validity of WGS-84 geodetic calculations computed with the PANDA system was assessed and the following calculations were considered:
  - coordinates of a point defined by azimuth and distance from a known point;
  - azimuth and geodetic distance between two known points; and
  - coordinates of a point defined by the intersection of two geodetic lines.

- The results were compared to the results from surveys on the field and compared to results from a geodetic calculator that was previously validated.
Validation of WGS-84 geodetic calculations (example)

### Function 1 ("Direct")

<table>
<thead>
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<th>LONGITUDE</th>
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<tbody>
<tr>
<td>0</td>
<td>84 °58'00.33&quot; S</td>
<td>W170 °00'00.00&quot;</td>
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<tr>
<td>10</td>
<td>84 °50'33.04&quot; S</td>
<td>W170 °00'21.21&quot;</td>
</tr>
<tr>
<td>100</td>
<td>84 °26'30.21&quot; S</td>
<td>W170 °00'00.00&quot;</td>
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<tr>
<td>50</td>
<td>84 °58'08.29&quot; S</td>
<td>W170 °23'52.62&quot;</td>
</tr>
<tr>
<td>174 °45'18.53&quot; W</td>
<td>83 °39'39.55&quot; S</td>
<td>W167 °38'41.18&quot;</td>
</tr>
<tr>
<td>60</td>
<td>84 °58'30.03&quot; S</td>
<td>W170 °22'54.40&quot;</td>
</tr>
<tr>
<td>174 °50'07.34&quot; W</td>
<td>83 °49'49.32&quot; S</td>
<td>W161 °06'08.92&quot;</td>
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<tr>
<td>90</td>
<td>84 °58'59.90&quot; S</td>
<td>W170 °44'36.56&quot;</td>
</tr>
<tr>
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<td>W170 °26'21.89&quot;</td>
</tr>
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<td>W155 °36'22.62&quot;</td>
</tr>
<tr>
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<td>85 °00'57.67&quot; S</td>
<td>W170 °26'21.89&quot;</td>
</tr>
<tr>
<td>174 °54'16.57&quot; W</td>
<td>86 °20'28.52&quot; S</td>
<td>W151 °57'37.71&quot;</td>
</tr>
<tr>
<td>196</td>
<td>85 °00'57.67&quot; S</td>
<td>W170 °26'21.89&quot;</td>
</tr>
<tr>
<td>174 °54'16.57&quot; W</td>
<td>86 °20'28.52&quot; S</td>
<td>W151 °57'37.71&quot;</td>
</tr>
<tr>
<td>210</td>
<td>85 °00'57.67&quot; S</td>
<td>W170 °26'21.89&quot;</td>
</tr>
<tr>
<td>174 °54'16.57&quot; W</td>
<td>86 °20'28.52&quot; S</td>
<td>W151 °57'37.71&quot;</td>
</tr>
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<td>85 °00'57.67&quot; S</td>
<td>W170 °26'21.89&quot;</td>
</tr>
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<td>W151 °57'37.71&quot;</td>
</tr>
</tbody>
</table>

### Input Data

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<tr>
<td>0</td>
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<td>W170 °00'00.00&quot;</td>
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<td>10</td>
<td>84 °50'33.04&quot; S</td>
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<td>100</td>
<td>84 °26'30.21&quot; S</td>
<td>W170 °00'00.00&quot;</td>
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<td>50</td>
<td>84 °58'08.29&quot; S</td>
<td>W170 °23'52.62&quot;</td>
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<td>174 °45'18.53&quot; W</td>
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<tr>
<td>60</td>
<td>84 °58'30.03&quot; S</td>
<td>W170 °22'54.40&quot;</td>
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<td>174 °50'07.34&quot; W</td>
<td>83 °49'49.32&quot; S</td>
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</tr>
<tr>
<td>90</td>
<td>84 °58'59.90&quot; S</td>
<td>W170 °44'36.56&quot;</td>
</tr>
<tr>
<td>174 °48'36.10&quot; W</td>
<td>83 °43'56.55&quot; S</td>
<td>W156 °37'35.28&quot;</td>
</tr>
<tr>
<td>120</td>
<td>85 °00'29.77&quot; S</td>
<td>W170 °26'21.89&quot;</td>
</tr>
<tr>
<td>174 °46'06.88&quot; W</td>
<td>83 °54'50.95&quot; S</td>
<td>W155 °36'22.62&quot;</td>
</tr>
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<td>150</td>
<td>85 °00'57.67&quot; S</td>
<td>W170 °26'21.89&quot;</td>
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<tr>
<td>174 °54'16.57&quot; W</td>
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<td>W151 °57'37.71&quot;</td>
</tr>
<tr>
<td>196</td>
<td>85 °00'57.67&quot; S</td>
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<td>174 °54'16.57&quot; W</td>
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<td>174 °54'16.57&quot; W</td>
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</tbody>
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PBN/PANS-OPS Workshop, Minsk 2015 43
### Function 2 ("Reverse")

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<tbody>
<tr>
<td></td>
<td></td>
<td>2nd POINT</td>
<td>Forward Azimuth</td>
<td>Reverse Azimuth</td>
<td></td>
</tr>
<tr>
<td>P1</td>
<td>S75 10 10.00</td>
<td>W145 30 30.00</td>
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<tr>
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<tr>
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<tr>
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<tr>
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<table>
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<th>Distance</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>2nd POINT</td>
<td>Forward Azimuth</td>
<td>Reverse Azimuth</td>
<td></td>
</tr>
<tr>
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</table>

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[Diagram showing software interface for calculating and point coordinates]
The following was assessed:

- THR-FAF distance;
- FAF tolerance area;
- Basic ILS Approach surfaces;
- OAS Cat I;
- OAS Cat II;
- Obstacle Free Zone (OFZ);
- Obstacle data set integration into walls to be correctly used by Collision Risk Model;
THR-FAF distance

System accuracy

Tolerance area
Basic ILS surfaces
### NAVIGATION AID DATA

**Approach Category:** Category I

- **Glide Path:** 3
- **LOC - THR Distance:** 3784 m
- **RDH:** 16.76 m

### AIRCRAFT DATA

<table>
<thead>
<tr>
<th>M/App CG (%)</th>
<th>CAT</th>
<th>STD</th>
<th>Wing Semi Span</th>
<th>GP Antenna height</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5</td>
<td>C</td>
<td></td>
<td>32.5 m</td>
<td>7 m</td>
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### OAS constants

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<th>0</th>
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<th>0.28539</th>
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</thead>
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<tr>
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</table>

### OAS Template coordinates - m (metres)

<table>
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<tbody>
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<td>X</td>
<td>Y</td>
</tr>
<tr>
<td>C</td>
<td>152</td>
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<tr>
<td>D</td>
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<tr>
<td>E</td>
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</table>

### OAS Height Calculator

\[X = \_, Y = \_, Z = \_] m

---

**OAS Cat I**

**ILS RWY 16**

**OAS CAT I**

**1:80 000**
The following table sums up the outcome of the Precision Segment validation:

<table>
<thead>
<tr>
<th>OBJECT</th>
<th>Precision Segment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference documentation</td>
<td></td>
</tr>
<tr>
<td>Documentation version</td>
<td>Yes</td>
</tr>
<tr>
<td>Method/concept</td>
<td>X</td>
</tr>
<tr>
<td>Input Data</td>
<td>Yes</td>
</tr>
<tr>
<td>Category of aircraft</td>
<td>X</td>
</tr>
<tr>
<td>Wing span</td>
<td>X</td>
</tr>
<tr>
<td>Distance glide path antenna/wheels</td>
<td>X</td>
</tr>
<tr>
<td>Selected runway and localizer orientation</td>
<td>X</td>
</tr>
<tr>
<td>THR coordinates</td>
<td>X</td>
</tr>
<tr>
<td>THR elevation</td>
<td>X</td>
</tr>
<tr>
<td>ILS category</td>
<td>X</td>
</tr>
<tr>
<td>LOC antenna coordinates</td>
<td>X</td>
</tr>
<tr>
<td>LOC beam width</td>
<td>X</td>
</tr>
<tr>
<td>Offset LOC</td>
<td>X</td>
</tr>
<tr>
<td>Glide path angle</td>
<td>X</td>
</tr>
<tr>
<td>RDH</td>
<td>X</td>
</tr>
<tr>
<td>Missed approach slope</td>
<td>X</td>
</tr>
<tr>
<td>FAP coordinates</td>
<td>X</td>
</tr>
<tr>
<td>Use of FAF</td>
<td>X</td>
</tr>
<tr>
<td>End of precision segment</td>
<td>X</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Output Data</th>
<th>Yes</th>
<th>No</th>
<th>Unknown</th>
<th>Out of scope</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference system</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>Design Environment</td>
</tr>
<tr>
<td>Coordinates of specific points</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>Calculated</td>
</tr>
<tr>
<td>Plane surfaces equation</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>Calculated</td>
</tr>
<tr>
<td>Elevation of plane surfaces</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>Calculated</td>
</tr>
<tr>
<td>Graphical check</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>THR-FAF distance</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>GIS environment</td>
</tr>
<tr>
<td>FAF tolerance area;</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>GIS environment</td>
</tr>
<tr>
<td>Obstacle Free Zone (OFZ)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>GIS environment</td>
</tr>
<tr>
<td>Basic ILS surfaces</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>GIS environment</td>
</tr>
<tr>
<td>OAS Cat I</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>GIS environment</td>
</tr>
<tr>
<td>OAS Cat II</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>GIS environment</td>
</tr>
<tr>
<td>Obstacle data set integration into walls to</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>GIS environment</td>
</tr>
<tr>
<td>be correctly used by Collision Risk Model;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conclusion</td>
<td></td>
<td></td>
<td></td>
<td>The function is accepted.</td>
<td></td>
</tr>
</tbody>
</table>
The validation of the PANDA SW has been carried out using the following LGS realistic work environment:

- Integrated AIM DB version 1.3.0
- Integrated AIM environment and Data Manager version 1.3.1
- ESRI ArcVew 10.2

The validation report is provided based on a template example presented in Appendix E of ICAO Doc 9906.
Chapter 2. Step-by-step description of activities within the validation process

2.1 Step 1: Conduct independent IPP design review
2.2 Step 2: Conduct preflight validation
2.3 Step 3: Conduct simulator evaluation
2.4 Step 4: Conduct flight evaluation
2.5 Step 5: Produce validation report

1.2.4 If the State can verify, through ground validation, the accuracy and completeness of all obstacle and navigation data considered in the procedure design, and any other factors normally considered in the flight validation, then the flight validation requirement may be dispensed with.
Many thanks for your attention

Questions, please

Vadim Tumarkin, LGS, Latvia