NAMIBIAN CIVIL AVIATION AUTHORITY

Advisory Pamphlet (AP)

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GUIDANCE ON VALIDATION OF FLIGHT PROCEDURE DESIGN SOFTWARE

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GUIDANCE ON VALIDATION OF FLIGHT PROCEDURE DESIGN SOFTWARE

1. PURPOSE

This Advisory Pamphlet (AP) provides guidance and information to Flight Procedure Design organisations on the validation of flight procedure design software to meet the requirements of the NAMCAR, Part 173.

2. BACKGROUND

(a) The NAM-CARs Part 173 requires a flight procedure design organisation to ensure that the software packages used in the design of procedures have been validated.

(b) The NAM-CAR Parts 173 also requires a flight procedure design organisation to ensure that a description of the procedures to be used to ensure that all equipment, including software is operated in accordance with the manufacturer's operating instructions and manuals,

(c) The NAM-CAR Part 173 further requires a flight procedure design organisation to ensure that the provisions of ICAO Doc 9906 are adhered to in terms of software validation.

(d) Below are the extracts from the Civil Aviation Regulations to which this Advisory Pamphlet apply.

3. EXTRACTS FROM NAM-CARS, PART 173 – FLIGHT PROCEDURE DESIGN SERVICES

173.04.11 Procedure design automation

(1) A flight procedure design organisation must ensure that the software packages used in the design of procedures have been validated.

(2) A flight procedure design organisation must ensure that a description of the procedures to be used to ensure that all equipment, including software is operated in accordance with the manufacturer's operating instructions and manuals, must be made readily available to the flight procedure designer.

(3) The flight procedure design organisation must ensure that the provisions of ICAO Doc 9906 referred to in regulation 173.04.9(1)(a)(viii) are adhered to in terms of software validation and use.

GENERAL GUIDANCE ON VALIDATION OF FLIGHT PROCEDURE DESIGN SOFTWARE

1. GENERAL GUIDANCE

1.1. Introduction

1.1.1. Procedure design automation tools are used in the design of instrument flight procedures to with the aim of quality control and to enhance the integrity of the procedure design process. The procedure design tools provided for procedure design facilitate the work of procedure designers during the process of procedure design from data management to the final output.

1.1.2. The term "procedure design tool" stands for any numerical automation system that provides calculations and/or designs and layouts in the field of procedure design. This encompasses products ranging from automated formulas included in spreadsheets to dedicated software packages.

1.1.3. Procedure design tools aim to aid the design of conventional and/or area navigation (RNAV) procedures for the departure, en-route, arrival, terminal and/or approach phases, through a series of dedicated integrated functions. They facilitate design work through a certain level of automation in calculations and procedure layout generation compliant with the applicable criteria. In addition, this automation in calculations contributes to the improvement of data integrity.

1.1.4. Procedure design tools including software tools can be misleading if they contain errors, or if procedure design criteria compliance is not ensured through all the functions provided by such tools. FPD organisation must therefore ensure that the software packages it uses in the design of its procedures have been validated and is operated in accordance with the manufacturer's operating instructions and manuals.

1.1.5. This Advisory Pamphlet (AP) provides guidance to assist FPD organisation in validating software they use in the design of instrument flight procedures. It provides guidance for preparing and carrying out an actual validation programme.

2. SOFTWARE VALIDATION PROCEDURES

2.1 Preparation

2.1.1. The procedure design tool validation requires time and effort. It needs to be prepared early enough to ensure proper implementation.

2.1.2. When preparing for validation, the FPD organisation should prepare a work plan defining:

a) the software validation coverage;
b) the overall objective schedule;
c) the available resources;
d) the validation team for the validation process, including the expertise according to the validation coverage;
e) the tasks to be carried out;
f) the roles and responsibilities of each team member for each task; and
g) a tentative detailed work programme (work items and timeframe).

2.2 Software validation coverage

2.2.1 The software validation coverage corresponds to the overall work programme related to the procedure design tool validation and must be based on the extent of the concerned procedure design tool's functions.

2.2.2 The software validation coverage needs to be defined to tailor the validation to the actual procedure design tool subject to validation.

2.3 Tool testing requirements

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

2.3.2 Prior to any validation task, it must be confirmed by the procedure design software developer that hardware and software are installed and configured according to the hardware and software specifications.

2.3.3 The validation should take into account the tests that the procedure design software developer may have performed. Whenever possible any evaluations previously performed by the developer should be repeated at the user site. The developer may be able to furnish the user with some of the test data sets to be used for this purpose.

2.3.4 The tool testing should follow a predefined written plan with a formal summary of testing and a record of formal acceptance. The tests should cover the full range of operating conditions so that the system can encounter a wide spectrum of conditions and events (detection of any latent faults not apparent during more normal activities).

2.3.5 Tool tests should be carried out at the user location, at least for part of the validation programme. User site testing should be accomplished in the actual working environment that will be part of the installed system configuration. The testing should be accomplished through use of the tool within the context in which it is intended to function. During user site testing, records should be maintained of both proper system performance and any system failures that are encountered. The revision of the system to compensate for faults detected during this user site testing should follow the same procedures and controls as for any other procedure design tool change.

2.3.6 Knowledge of test planning, definition of expected test results, and recording of all test outputs are required. Support in these areas from the procedure design software developer/provider would be beneficial.

2.4 Validation methodology

2.4.1 The validation methodology includes validation of basic parameters and basic elements as well as modeling of criteria validation through assessment of methods and concepts, input data, output data and graphical checks.

2.5 Units of measurement rounding considerations

2.5.1 Most software tools can perform calculations using any unit system, but many tools (and users) around the world commonly use the international system of units (SI) values for convenience of calculation and only later do they convert to non-SI values for display of results. Some tools however may make calculations based on the unit system selected by the user. Different tools will also treat some values with different levels of accuracy and resolution of the data, and rounding of values may also differ. However, generally, procedure design tools will use values and perform calculations to greater degrees of accuracy than are available through manual calculations.

2.5.2 Thus, during the validation process, the implementation of unit systems, the conversion factors used, the accuracy and resolution of data used, and rounding considerations are all factors to be considered in terms of how the validation is undertaken and with regard to evaluation of results.

2.5.3 The conversion between unit systems implemented in the software must comply with the provisions of NAMCAR Part 2 – Units of measurement. The Table below provides the most common conversion factors used in the procedure design process:

Common conversion factors

Conversion factor	***Value***	***Source***
Nm to Metre (m)	1 852.0	NAMCAR Part 2
Foot (ft) to Metre (m)	0.3048	NAMCAR Part 2
Metre (m) to Foot (ft)	= 1 / 0.3048	NAMCAR Part 2
Knot (kt) to m/s	0.514444	NAMCAR Part 2

2.6 Validation of Basic data and parameters

2.6.1 The list of the raw data and parameters used for calculations in the tool must be provided, and the parameters' values must be easily available for checks.

2.6.2 The Table below provides a representative sample of the raw data that may be used in procedure design tools, and the reference value (when applicable) or range of values associated with these elements:

Raw data and reference values for procedure design calculations

<table>
<tr><th colspan="2">Constant</th><th colspan="2">Value</th></tr>
<tr><td colspan="2">PI</td><td colspan="2">3.1416</td></tr>
<tr><td colspan="2">Mean Earth Radius
(Doc 9674, WGS-84 manual)</td><td colspan="2">6 378 137 m</td></tr>
<tr><td colspan="2">Flattening
(Doc 9674, WGS-84 manual)</td><td colspan="2">$\frac{1}{298.257223563}$</td></tr>
<tr><td colspan="2">g</td><td colspan="2">9.80665 m/sec^2</td></tr>
<tr><td colspan="2">Nautical Mile
(Annex 5, Table 3.3)</td><td colspan="2">1 852.0 m</td></tr>
<tr><td colspan="2">Reference pressure to define the flight levels and QNH
(Doc 4444)</td><td colspan="2">1 013.2 hPa</td></tr>
<tr><td colspan="2">Missed approach climb gradient (Z)
(Doc 8168, Volume II, Part 1, Section 4, Ch. 6)</td><td colspan="2">Default value 2.5%
Additional values 2%, 3%, 4%, 5%</td></tr>
<tr><td rowspan="6">Height loss (HL)</td><td rowspan="2">CAT A</td><td>Pressure altimeter
(m/ft)</td><td>Radio altimeter
(m/ft)</td></tr>
<tr><td>40 (130)</td><td>13 (42)</td></tr>
<tr><td>CAT B</td><td>43 (142)</td><td>18 (59)</td></tr>
<tr><td>CAT C</td><td>46 (150)</td><td>22 (71)</td></tr>
<tr><td>CAT D</td><td>49 (161)</td><td>26 (85)</td></tr>
<tr><td>CAT H</td><td>35 (115)</td><td>8 (25)</td></tr>
<tr><td colspan="2">OIS altitude at the DER (H)</td><td colspan="2">5 m (16 ft)</td></tr>
</table>

2.6.3 The Table below provides the minimum obstacle clearance (MOC) values included in PANS-OPS:

MOC values

Segment of flight	**MOC value in the primary area** (for the secondary area it will be reduced linearly from the entire value to 0 on the outer border of the secondary area)	**Mountainous areas**
Initial approach segment	984 ft (300 m)	Up to the procedure designer
Intermediate approach segment	492 ft (150 m)	Up to the procedure designer
Non precision final approach segment	246 ft (75 m) or 295 ft (90 m) in case of no FAF procedure.	Up to the procedure designer
Missed approach segment	98 ft (30 m) or 164 ft (50 m) depending on the position of the obstacle in the missed approach area.	Up to the procedure designer
Departure	0.008*D where D is the distance from the obstacle to the Departure end of Runway (DER) or 295 ft (90 m), whichever is greater.	Up to the procedure designer
Arrival	984 ft (300 m)	Up to the procedure designer
En-route	984 ft (300 m)	• 450 m (1 476 ft) between 900 m (3 000 ft) and 1 500 m (5 000 ft) • 600 m (1 969 ft) greater than 1 500 m (5 000 ft)

2.6.4 The values incorporated in the software may be higher than the values provided in the following table for the various segments of flight:

2.7 Basic element validation

2.7.1 This section, along with Appendix II, provides some guidelines for the validation of the calculations which are implemented to construct the areas, and for the validation of elementary concepts connected with the design of instrument flight procedures. Some of these elements may be compiled in a function of the tool.

2.7.2 The functions request values for the input data and provide a result. The tool should check that these data values and results lay inside the limits specified in the criteria. In case the function allows input values outside these limits, this information should be made available to the procedure designer.

2.7.3 During the validation process, the following calculations should be checked with reference to PANS-OPS:

a) taking altitude into account when calculating true air speed;
b) converting indicated air speed into true air speed;
c) calculating a turn radius;
d) calculating the wind effect during a turn, and corresponding drawing;
e) calculating the wind drift along a non-guided straight path, and corresponding drawing;
f) calculating a fix tolerance area for vectoring and at the intersection, for all known fixes in conventional navigation; and
g) calculating cross-track tolerance (XTT) and along-track tolerance (ATT) for all types of waypoints.

Note. Doc 9906, Volume III, Appendix D, provides details about the reference criteria, values and formulas corresponding to several basic functions and the determination of straight-in approach, OCH adjustments, and computation of slope and rate of descent.

2.7.4 During the validation process, the method used for some elementary concepts where reference criteria are particularly difficult to model should be described on request. Examples include taking oblique distances into account (DME, TACAN), calculating a rate of descent, partitioning the area associated with a segment, and the management of altitudes.

2.8 Modelling of criteria validation

2.8.1 The modelling of criteria validation consists in verifying that the results obtained through the use of the tool are compliant with the criteria. To this end, guidelines and representative examples are provided in this AP.

2.8.2 The examples provided in this AP are representative ones but should not be considered as being exhaustive or as covering all situations. The examples included in this AP are provided for a given set of raw data. A subsequent validation could lead to different results if the raw data have changed.

2.8.3 The modelling of criteria validation must be based on the comparison of results achieved using the tool with results obtained through manual implementation of the criteria (drawings, calculation results, etc.) for realistic examples. The differences between these results must be identified and analysed, so that they can be either accepted or rejected, on the basis of advice from procedure design experts.

2.8.4 The analysis of differences must take into consideration the several known potential sources of differences that are listed below:

a) *Units (*) used for calculation*. It is acknowledged that different unit systems may lead to slight differences in results when converted to a single unit system;
b) *Conversion factors between units*. Application of a strict regulatory or conventionally used conversion factor (e.g. 984.25 ft vs. 1 000 ft for conversion of 300 m) may lead to differences in final results;
c) *Rounding rules*. Depending on the rounding process (single final application or intermediate applications), end results may differ slightly;
d) *Projection*. The projection used for display of the results may lead to slight differences when comparing the tool’s results with manual results;
e) *Intermediate steps*. Within some automated tools, the display of the template is mathematically computer driven, while manual design usually involves mandatory steps of graphical handling (wind spirals and template are calculated before being

drawn and used for the design of a specific area); this may lead to difficulty for a direct visual comparison with a model of template.

(*) It must be noted that Doc 8168 introduces ambiguities by rounding SI units to non-SI units and vice versa in a non-coherent manner (e.g. 300 m = 1 000 ft).

2.8.5 Additionally, differences can occur in cases where the reference criteria are not explicit enough, because this may lead to different implementations (*). This situation is all the more pertinent with automation as the reference criteria originally designed for manual implementation can be applied for all kinds of cases, even for non-realistic ones.

(*) For instance, consideration of the altitude for the calculation of the uncertainty to the vertical of a navaid is open to interpretation and it may lead to discrepancies in the end-result.

2.8.6 The analysis of end-result differences must then be made with particular caution, since it is not likely that results obtained through one software match exactly those obtained manually or with another independent software. However, the purpose of the comparison must be to determine whether the differences are acceptable or not given the known sources of potential differences. The acceptability of the differences must be based on the demonstration that the tool results provide a protection that is equal to or greater than the one obtained through manual design or with a previously validated independent tool, or that the differences are minor (*) and can be accepted.

(*) It is acknowledged that increased accuracy of computation by software tools may in some cases lead to results that are marginally less conservative than manual results.

2.8.7 The modelling of criteria validation must include tests (comparison of results) for each type of design, layout or calculation available in the tool. The tests must systematically state:

a) the reference criteria, including the version number (PANS-OPS edition and amendment number);
b) the reference material paragraph containing the figure/description;
c) the input data (aeronautical and geographical data, as appropriate);
d) all the constructive parameters; and
e) the element data to survey.

Note. When terrain data are used for tests, the terrain data points involved in the computation must be marked.

2.8.8 All the test results must include a complete list of the most significant terrain data points or obstacles that have been used. This list must contain the coordinates, the altitude, the required MOC (if applicable) and the penetration (if applicable). A log file for each test should be created. Coordinates and positions within the list of results should be reflected onto the graphic for an easy check.

2.8.9 The application of criteria modelling validation is based upon three key-points: knowledge of the applicable regulation; experience in procedure design; and the practice of the tool subject to validation. An overall process mixing these key points may be sufficient to successfully carry out this validation using a step-by-step methodology.

Note. The step-by-step methodology is described in Doc 9906, Volume III, Chapter 7, Section 7.5.

2.8.10 *Application to the standard modelling validation for calculations*

2.8.10.1 The calculations carried out to get minimum altitudes (or gradients) include several steps:

a) identification of the terrain and obstacle data that are relevant for the given segment or procedure;
b) application of the relevant MOC to the previously identified terrain and obstacle data, taking into account the differences linked to primary and secondary areas; and
c) Identification of the controlling obstacle (or terrain) and calculation of the MOCA (or OCA or PDG) taking into account the PANS-OPS rounding rules.

2.8.10.2 These steps should be submitted to validation in a manner identical to the one developed in section 2.8.9 above, as appropriate: method/concept assessment; input and output data checks; and graphical checks.

2.8.11 The methodology proposed in this AP is not sufficient for functions where the tests cannot be implemented by a series of manual calculations, visual checks or key-points to be surveyed. This is the case for the CRM and the FAS data block generator. For these specific cases, external validation processes, based on processes such as the Software Safety Assurance System are necessary.

2.9 Validation documentation

2.9.1 During the validation implementation, detailed documentation of the tests being carried out should be compiled. This documentation should include the history of the tests, including input data and test results. A sample of validation documentation is provided in Appendix 1 to this AP.

2.9.2 For the purpose of continuous improvement of the software, the FPD organisation is encouraged to make the validation documentation available to the procedure design software developer/provider.

APPENDIX 1

SAMPLE VALIDATION DOCUMENTATION

Software Name	Instrument Procedure Design System			Version	1.0
Name of Tester	John Q. Public	Organization/State	Federal Aviation Administration/United States of America		
Signature	*John Q Public*			Date	16 May 2007
Test # 1 Title	Circling	Objective	Validate construction and obstacle assessment of circling area		
Reference Doc.	PANS-OPS, Volume II [*Part I, Section 4, Chapter 7*]				
Related Test #	Tests # 7 and 8				

Initial Conditions
Application is open, and populated with database set ***"A1"***. Procedure titled ***VOR/DME straight-in final Test #8*** has been created and saved.

Step	Required Action	Expected Results	Pass	Fail
1	CAT A area	Application correctly constructs area	x	
2	CAT A obstacle assessment	Application correctly assesses obstacles	x	
3	CAT B area	Application correctly constructs area	x	
4	CAT B obstacle assessment	Application correctly assesses obstacles	x	

Comments
None