

Doc 9906
AN/472



Quality Assurance Manual for Flight Procedure Design

Volume 3 Flight Procedure Design Software Validation

Approved by the Secretary General
and published under his authority

First Edition — 2010

International Civil Aviation Organization

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Volume 3 — *Flight Procedure Design Software Validation***

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AMENDMENTS

Amendments are announced in the supplements to the *Catalogue of ICAO Publications*; the Catalogue and its supplements are available on the ICAO website at www.icao.int. The space below is provided to keep a record of such amendments.

RECORD OF AMENDMENTS AND CORRIGENDA

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PREFACE

The *Quality Assurance Manual for Flight Procedure Design* (Doc 9906) consists of six volumes:

Volume 1 — *Flight Procedure Design Quality Assurance System*;

Volume 2 — *Flight Procedure Designer Training (Development of Flight Procedure Designer Training Programme)*;

Volume 3 — *Flight Procedure Design Software Validation*;

Volume 4 — *Flight Procedures Design Construction (to be developed)*;

Volume 5 — *Validation of Instrument Flight Procedures*; and

Volume 6 — *Flight Validation Pilot Training and Evaluation (Development of a Flight Validation Pilot Training Programme)*.

Instrument flight procedures based on conventional ground-based navigational aids have always demanded a high level of quality control. The implementation of area navigation and associated airborne database navigation systems, however, means that even small errors in data can lead to catastrophic results. This significant change in data quality requirements (accuracy, resolution and integrity) has led to the need for a systemic quality assurance process. The *Procedures for Air Navigation Services — Aircraft Operations* (PANS-OPS, Doc 8168) Volume II, Part I, Section 2, Chapter 4, *Quality Assurance*, refers to this manual and requires that a State take measures to “control” the quality of the processes associated with the construction of instrument flight procedures. To this end, this manual has been assembled to provide guidance in attaining these stringent requirements for quality assurance in the procedure design process. All four volumes address crucial areas related to the attainment, maintenance and continual improvement of procedure design quality. Data quality management, procedure designer training, and validation of software are all integral elements of a quality assurance programme.

Volume 1 — *Flight Procedure Design Quality Assurance System* provides guidance for quality assurance in the elements of procedure design, such as procedure design documentation, verification and validation methods, and guidelines about the acquisition/processing of source information/data. It also provides a generic process flow diagram for the design and implementation of flight procedures.

Volume 2 — *Flight Procedure Designer Training* provides guidance for the establishment of flight procedure designer training. Training is the starting point for any quality assurance programme. This volume provides guidance for the establishment of a training programme.

Volume 3 — *Flight Procedure Design Software Validation* provides guidance for the validation (not certification) of procedure design tools, notably with regard to criteria.

Volume 4 — *Flight Procedures Design Construction* (to be incorporated later).

Volume 5 — *Validation of Instrument Flight Procedures* provides guidance for the implementation of a validation process of instrument flight procedures.

Volume 6 — *Flight Validation Pilot Training and Evaluation* provides guidance for the establishment of a flight validation pilot training programme.

Note.— In the independent volumes, when a reference is made to the term “manual” in the context of this document, without any further specification, it is presumed to refer to this volume of the Quality Assurance Manual for Flight Procedure Design.

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ABBREVIATIONS

AIXM	Aeronautical information exchange model
ARP	Aerodrome reference point
ATS	Air traffic services
ATT	Along-track tolerance
CAD	Computer-aided design
CMMI	Capability maturity model integration
CRM	Collision risk model
CTR	Control zone
DAFIF	Digital aeronautical flight information files
DME	Distance measurement equipment
DTM	Digital terrain model
eTOD	electronic terrain and obstacle data
FTA	Fix tolerance area
GIS	Geographic information system
IAS	Indicated air speed
IEEE	Institute of electrical and electronic engineers
ILS	Instrument landing system
LOC	Localizer
MOC	Minimum obstacle clearance
MOCA	Minimum obstacle clearance altitude
MSA	Minimum sector altitude
NDB	Non-directional radio beacon
OAS	Obstacle assessment surface
OCA/H	Obstacle clearance altitude/height
OLS	Obstacle limitation surfaces
PDG	Procedure design gradient
RNAV	Area navigation
SI	International system of units (Système International)
TACAN	(UHF) tactical air navigation aid
TMA	Terminal area
UTM	Universal transverse mercator
VOR	VHF Omnidirectional radio range
WGS-84	World Geodesic System — 1984
WP	Waypoint
XTT	Cross-track tolerance

DEFINITIONS

Acceptance. The act of accepting with formal approval (favourable reception).

Automation. The automatic operation or control of equipment, a process, or a system.

Basic element. The lowest level object identified within a specific function.

Basic parameter. Reference parameter or constant defined in the applicable criteria for procedure design calculations.

Modelling of criteria. A schematic description of criteria that accounts for its properties and may be used for further study or application of its characteristics.

Procedure design function. An element of a procedure design software executing a predefined task and providing output to the procedure designer.

Note.—The description of a procedure design function needs to include all required input (values, format, etc.) and a comprehensive description of the expected outputs. For example, outputs may include:

- *result of checks for consistency of input with the applicable regulation;*
- *results of various calculations (area width, MOCA, etc.); and*
- *protection area drawing.*

Procedure design tool. Automation system that provides calculations and/or designs and layouts in the field of procedure design.

Software environment. Software used to support an automation tool, such as an operating system, or database management system.

Software validation. Acknowledgement, derived from a series of tests, of the compliance of an automation system with the applicable standards.

Functional validation. Confirmation of the correct implementation of automation functions and of the compliance of the human machine interface with the user requirements.

Validation with reference to criteria. Confirmation through a series of tests of the compliance of the results with reference to applicable criteria.

Test. A basis for critical evaluation.

Validation. Confirmation, through the provision of objective evidence, that the requirements for a specific intended use or application have been fulfilled (see Annex 15 — *Aeronautical Information Services*). The activity whereby a data element is checked as having a value that is fully applicable to the identity given to the data element, or a set of data elements that is checked as being acceptable for their purpose.

Verification. Confirmation, through the provision of objective evidence, that specified requirements have been fulfilled (see Annex 15). The activity whereby the current value of a data element is checked against the value originally supplied.

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FOREWORD

The Foreword to the *Procedures for Air Navigation — Operations* (PANS-OPS, Doc 8168) Volume II, states that “The implementation of procedures is the responsibility of Contracting States.” This implies that the State authorities have the final responsibility for the procedures published within their territory.

The procedure design process may be carried out by States themselves or by delegation from States to third parties such as air traffic services (ATS) providers, private companies or another State.

When automation is used during the procedure design process, States must ensure that automation functions have been validated to ensure compliance of the final results with applicable criteria.

Implementation of the validation can be carried out by States themselves or by delegation to any recognized third party (such as another State, an ATS provider or a private company).

This manual is guidance material; it provides one means, but not the only means, for validation of the functions of procedure design tools. Other means include a Software Safety Assurance System, as part of a Safety Management System (comprising requirements for software assurance level, software verification assurances, software configuration management assurances, software requirements traceability assurances, software requirements validity assurance).

Note.— The manual may also be useful for software development companies wishing to demonstrate conformance to applicable criteria. It may also be of interest to any person or organization involved in the procedure design domain.

This manual has been developed with active input from representatives of the procedure design software industry. It is recognized that other software validation documents not specific to the flight procedure design domain exist, such as the ones defined by IEEE, CMMI, EUROCONTROL and RTCA.

Comments on this manual, particularly with respect to its application, usefulness and scope of coverage, would be appreciated from States and ICAO Technical Cooperation field missions. These will be taken into consideration in the preparation of subsequent editions. Comments concerning this manual should be addressed to:

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Montréal, Quebec, Canada
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STRUCTURE OF THE MANUAL

This manual is organized as follows :

Chapter 1 — Introduction presents a rationale for automation in the procedure design domain and the need for validation of the procedure design tools. It states the main principles regarding the applicability of the manual.

Chapter 2 — Scope specifies the goal of the manual and reviews the various types of validation and their applicability to procedure design tools. The chapter includes requirements about the reporting of validation and the iterative validation process, as well as some guidance on reporting of inconsistencies within PANS-OPS.

Chapter 3 — Overview of procedure design tools provides general information about these tools, their main functions and the main types of existing tools.

Chapter 4 — Implementing a validation programme provides practical guidance to prepare and carry out an actual validation programme applied to procedure design tools.

Chapter 5 — Environment of procedure design sets general requirements about the documentation of the tools, the management of geographical information, and WGS-84 calculations.

Chapter 6 — Tool inputs provides requirements about the input and update of aeronautical and terrain data.

Chapter 7 — Procedure design functions is the main part of the manual. It includes four main parts: considerations about units and rounding processes, basic parameter validation, basic element validation and modelling of criteria validation.

Drafting conventions

The following drafting conventions are used in this manual:

- “must” indicates a statement of specification, the compliance with which is required to achieve the implementation of the specification;
- “should” indicates a recommendation or best practice; and
- “may” indicates an optional element.



Chapter 1

INTRODUCTION

1.1 AUTOMATION IN THE PROCEDURE DESIGN DOMAIN

1.1.1 Thanks to the latest developments in computer techniques, procedure design tools are increasingly being used by designers with the goal of quality control and integrity enhancement in the procedure design domain.

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 include devices which facilitate the work of the designer during the whole process of procedure design, from data management to the final output (preparation of the publication).

1.1.5 Use of automation is not intended to replace the procedure designer’s expertise.

1.2 THE NEED FOR VALIDATION OF PROCEDURE DESIGN TOOLS

1.2.1 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.

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

1.3 APPLICATION OF THE MANUAL

1.3.1 This manual is based on the criteria defined by ICAO, especially those contained in the *Procedures for Air Navigation — Aircraft Operations* (PANS-OPS, Doc 8168).

Note.— The version of PANS-OPS referenced in this manual is the fifth edition, Volumes I and II.

1.3.2 Amendments to the reference criteria must be reflected as soon as possible in the software tools.

1.3.3 The guidelines provided in this manual constitute a framework that can be adapted to other criteria (e.g. national criteria) as appropriate.

Chapter 2

SCOPE

2.1 GOAL OF THE MANUAL

2.1.1 The goal of the manual is to provide guidelines for the validation of procedure design tools in compliance with criteria.

Note.— 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.

2.1.2 The scope of this manual **excludes** the certification of procedure design tools.

Note.— Certification is defined as an official acknowledgement that the standards derived from a given procedure (certification procedure) have been complied with, and implies the delivery of a certificate of compliance. As such, a procedure design tool certification would imply that the tool is in compliance with applicable standards in all the studies that can be carried out with it. The certification assumes the existence of applicable standards and a certification procedure. Moreover, the certification must cover the whole tool, including the software development phase (with a DO-278B-like approach) and must be set up as from the initial development (algorithm generation) of the tool.

2.2 FUNCTIONAL VALIDATION

2.2.1 Functional validation consists of confirmation that the automation functions in the tool have been correctly implemented (e.g. when selecting an item in a menu, the item appears), and that the human machine interface complies with the user's requirements. As such, this validation type is dependent upon the user needs and can be carried out during the acceptance phase by the end users. Moreover, the functional validation does not refer to procedure design criteria, but to general specifications (interface and ergonomics, general computerized tool specifications, etc.).

2.2.2 Functional validation falls outside of the scope of this manual. However, it may be considered by users in addition to the guidelines provided in this manual.

2.3 VALIDATION WITH REGARD TO CRITERIA

2.3.1 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 must cover all the relevant functions of the tool (including general functions and some input/output functions). These tests should include the comparison between the results obtained with the tool and the ones obtained manually or with a previously validated independent tool. These tests must be carried out according to a predefined list and guidance.

2.3.2 The series of tests recommended in this manual should be considered as a minimum, and the actual validation may include additional tests if deemed relevant.

2.4 AERONAUTICAL AND GEOGRAPHICAL DATA USED IN PROCEDURE DESIGN TOOLS

2.4.1 The quality of procedure designer work is highly dependent on the quality of information used by the designer. With the advent of automation, information is now mostly stored in databases, both for aeronautical data and geographical data.

2.4.2 Notwithstanding the data quality itself (this falls outside the scope of this manual), the methods used to integrate and update the data constitute a critical element in obtaining the correct results computed by tools. Thus, guidance for validation of data input and updates is included in this document.

2.4.3 Processing aeronautical data (e.g. WGS-84 geodetic calculations, transformation between reference systems and projection-based systems) can be critical for the validity of procedure design. Guidance about these processes is included in this manual.

2.4.4 As far as geographical data are concerned, some procedure design tools use terrain data (digital terrain models, triangular irregular networks, etc.) for display purposes, while others use them as a part of internal calculation and for procedure layout generation. The validation of the use of terrain data only addresses tools that use the data for calculations. The validation of the use of geographical data for display purposes only falls outside the scope of this manual.

2.4.5 It has been shown that some inconsistencies concerning the correct input of terrain data (in terms of geographical reference coherency) may not be detected by procedure designers, but actually do occur and could introduce large discrepancies in the final results when these data are used in the calculations. Considering the potential consequences of such errors, and the difficulty in detecting them, particular care must be taken in the validation of terrain data integration in procedure design tools, whenever they are used as part of calculations.

2.5 APPLICABILITY OF THE VALIDATION TO PROCEDURE DESIGN TOOLS

2.5.1 This validation manual may be applicable to individual functions of a given tool, or to the whole tool. It is acknowledged that an individual tool may not include all the procedure design functions and consequently some validation items may not be applicable to each and every tool. It is also recognized that a given user may not require a function included in a given tool. The applicability of each item of the validation manual should thus be determined at the time of the validation execution.

2.5.2 The composition of the validation should include all the critical functions in the procedure design process, but some items can, at least during a first phase, be taken over from other domains (e.g. quality of the aeronautical data taken over from the aeronautical information services domain).

2.5.3 The validation of a tool should be carried out for a given software environment (operating system, geographic information system (GIS) or computer-aided design (CAD) supporting system, database management system, etc.). Should this environment change, a further validation may have to be carried out (see 2.7.3).

2.6 REPORT OF THE VALIDATION WITH REGARD TO CRITERIA

2.6.1 The validation process must be recorded in a report that clearly states the criteria that were considered as reference (with dates and reference to the last considered amendment), and the extent of coverage of the software tool with respect to these criteria.

2.6.2 The report must precisely mention all the items that were tested (with detailed results) and the items that were excluded from the validation process. Any limitation to a given function (e.g. altitude restriction for holding patterns) must be recorded.

2.6.3 The validation report must mention the characteristics of the tests (dates, name of individuals that have conducted the tests, etc.). The version of the tool, of the software environment (GIS, CAD, database management system, etc.), and of the operating system that were used must be recorded in the report.

2.6.4 Notes and comments from the final users about the compliance with criteria should be recorded in the validation report.

2.6.5 A template for the validation report is provided in Appendix E.

2.7 REQUIREMENTS FOR REVALIDATION

2.7.1 Whenever the applicable procedure design criteria are updated, the impact on the procedure design tool must be identified by the procedure design software developer/provider and evaluated. Should the changes have an impact on procedure design tool functions, the corresponding functions of the tool must be revalidated.

2.7.2 Whenever a new version of the software tool is issued, the changes with reference to the previous version must be identified and their consequences must be evaluated. Should the new version include new functions or amendments to previous functions, the tool must be revalidated.

2.7.3 As the computing environment of the software (operating system, GIS or CAD supporting system, database management system, etc.) evolves, the consequences on the tool must, whenever possible (*), be identified and evaluated. If deemed necessary, full or partial revalidation should then be conducted.

() It is acknowledged that some updates may not be documented or notified. In those cases, the identification and evaluation of consequences may not be possible.*

2.8 AMBIGUITIES IN REFERENCE MATERIAL

2.8.1 It is recognized that the validation process may lead to pointing out ambiguities in the current PANS-OPS.

2.8.2 Any problem encountered during the validation process that is assumed to be due to ambiguities in PANS-OPS should be reported to ICAO for consideration throughout the appropriate process.

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Chapter 3

OVERVIEW OF PROCEDURE DESIGN TOOLS

3.1 MAIN FUNCTIONS OF PROCEDURE DESIGN TOOLS

Introduction

3.1.1 Procedure design tools provide users with functions that can be split into three main categories: environment for design, inputs and outputs, and specific procedure design.

Environment for design

3.1.2 The category “environment for design” corresponds to the whole set of general aspects that a procedure designer has to take into consideration during design, but which are not specifically related to standard criteria.

3.1.3 This includes the following aspects:

- geographical information: coordinate reference system integration, WGS-84 calculations, conversion between various reference systems, charting projections, etc.;
- graphical tools: creation and management of graphical objects (segments, curves, texts, etc.), 2-D or 3-D display of geographical information;
- reference material: direct access to reference criteria and documentation used for design;
- recording and archiving the work of the designer for subsequent studies; and
- reports of procedure design studies.

3.1.4 The correct implementation of the environmental functions contributes to the correct functioning of the tools. Thus, the validation of these functions is necessary, and it is included in this manual.

3.1.5 It should be noted that these functions are generally issued from validated systems such as GIS for geographical information, CAD systems for graphical tools, digital copies of paper reference material and general automation functions for recording and archiving.

Tool inputs and outputs

3.1.6 The tool inputs and outputs correspond to the integration and release of digital information and data to/from the software tools. These functions include the management of input and output data format for some of the aeronautical and terrain data the designers utilize (collision risk model (CRM) obstacles, AIXM, ARINC 424, DAFIF).

3.1.7 The input function corresponds to the capabilities to integrate information and/or data useful for the procedure design. It encompasses the original acquisition of information/data, and the update processes.

3.1.8 This includes the following items :

- integration of raster data: “bitmap” charts, images, digital terrain models (DTM), etc.;
- integration of vector files: vector DTM, topographical data, etc.;
- integration, management and update of aeronautical information: navaids, aerodromes, obstacles, airspace, etc.

3.1.9 The input of data in a procedure design tool may be carried out either through the automatic loading from a database or through manual data capture. In both cases, it is of paramount importance to ensure that the integrity of the data imported into the tool meets the requirements set for the data in the applicable ICAO Standards (Annex 11 — *Air Traffic Services* and Annex 14 — *Aerodromes*).

3.1.10 The input functions are critical for the correct functioning of software tools. For instance, if the aeronautical database updates are not correctly processed, the results may be wrong because of the use of outdated raw information. This is why the validation manual addresses the input functions.

3.1.11 The output functions allow the procedure designers to get some output results (layouts or files) of the design: layout displays; calculation result files; procedure design coding according to various formats (e.g. ARINC 424). They include the following functions:

- 2-D or 3-D procedure design layout display;
- output file including all the calculation results;
- graphical representation of the procedures (from the design mode to an aeronautical chart); and
- procedure coding (ARINC 424, AIXM, etc.).

3.1.12 The validation manual considers the outputs as part of the results produced by the procedure design tools. However, the conformance of graphical representation of the procedures to applicable Standards (as defined in Annex 4 — *Aeronautical Charts*) falls outside the scope of this manual.

Procedure design

3.1.13 The category “procedure design” corresponds to the core of the design process: compliance with reference criteria, procedure layouts (with protection area templates), and procedure calculations. The available functions will depend upon the type of tool (see section 3.2).

3.1.14 This includes the following aspects:

- integration of ICAO parameters for calculations;
- modelling of the considered criteria (if applicable): criteria algorithm implementation, compliance checks, information to the user in case of non-compliance (warning and error messages). In some tools, the modelling may not be included, or only partially included, and in those cases the algorithms are replaced by drawing tools with coherency checks;
- RNAV/conventional, en-route/terminal/approach procedure layouts, with protection areas, for all the procedure elements:

- Holding patterns
 - Reversals
 - Arrivals and departures
 - Initial, intermediate and final segments
 - Precision approach
 - Missed approach
 - Links between segments
 - Circling
 - VHF omnidirectional radio range/non-directional radio beacon (VOR/NDB) routes;
- RNAV/conventional, en-route/terminal/approach procedure calculations:
 - Obstacle clearance altitude/height (OCA/H)
 - Procedure design gradient
 - Descent slope or rate of descent
 - Minimum safety altitudes – procedure altitude
 - Other parameters including indicated airspeed (IAS), start and end of segment altitude, bank angle, etc.;
- CRM calculations; and
- Annex 14 surfaces (obstacle limitation surfaces) computation, drawing and evaluation with respect to obstructions and terrain.

3.1.15 The correct implementation of the design functions is the essential part to verify in the validation process. The difficulty lies in the fact that the degree of automation of this type of function may vary widely between the tools.

3.2 THE TWO MAIN TYPES OF PROCEDURE DESIGN TOOLS

3.2.1 Notwithstanding the various functions of procedure design tools (see section 3.1), two main types of procedure design tools can be defined: the aiding tools and the expert tools.

Aiding tools

3.2.2 In this category, the level of automation is not exhaustive, and there are a limited number of restrictions linked to the applicable criteria, but the user is provided with aiding functions that contribute, as long as the designer's knowledge and expertise are sufficient, to efficient work in terms of quality and time.

3.2.3 Nevertheless, some consistency checks for compliance with general rules (maximum length of segments, alignment of the final approach segment with respect to the runway, etc.) are generally included in the software tool.

3.2.4 Since the software tools belonging to this category essentially rely on the designer's expertise, the validation process parameter applicable to them might be less extensive. However, there is still a need for validation so as to ensure that the designs do not fall outside the criteria because of incorrect implementation of general rules (see above) or due to issues associated with the tool environment and input/output functions (geographic information management, aeronautical and geographical data integration, etc.).

Expert tools

3.2.5 In this category the level of automation is high. The aim is for an optimum compliance with the considered criteria, and that most of the criteria are actually implemented in the software through criteria modelling and subsequent algorithm generation.

3.2.6 The wide range of integrated checks provides the user with information on the strict conformance with criteria, but also offers capabilities to overstep some criteria (via dispensations).

3.2.7 Since the software tools belonging to this category include actual extensive modelling of some criteria, the validation process applied to them is vital, as an error could remain undetected even by expert procedure designers.

Chapter 4

IMPLEMENTING A VALIDATION PROGRAMME

This chapter provides practical guidance for preparing and carrying out an actual validation programme applied to procedure design tools. It is applicable to initial validation as well as revalidation for new functions and/or updates to the procedure design tool and/or to the system environment.

4.1 PREPARATION

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

4.1.2 For this purpose, it is recommended to develop a work plan defining:

- the software validation coverage;
- the overall objective schedule;
- the available resources;
- the validation team for the validation process, including the expertise according to the validation coverage;
- 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).

4.2 SOFTWARE VALIDATION COVERAGE

4.2.1 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 (see 2.5.1).

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

4.3 TOOL TESTING REQUIREMENTS

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

4.3.2 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.

4.3.3 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.

4.3.4 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).

4.3.5 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.

4.3.6 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.

4.4 VALIDATION METHODOLOGY

The validation methodology is presented in Chapter 7. It 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.

4.5 VALIDATION DOCUMENTATION

4.5.1 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 E.

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

Chapter 5

ENVIRONMENT OF PROCEDURE DESIGN

5.1 TOOL DOCUMENTATION

5.1.1 The tool documentation should follow from the technical reference criteria and material. The tool documentation provided must conform to the functionalities of the tool.

5.1.2 The validation of the tool documentation must be carried out through a thorough review of the reference criteria.

5.1.3 A comparison with the applicable criteria must demonstrate that there is no discrepancy between these criteria and the tool documentation. If discrepancies exist, the validation results must describe the differences and the appropriate rationale, and it must be demonstrated that the consequences for procedure design are acceptable.

5.2 GEOGRAPHICAL INFORMATION

5.2.1 The validation of geographical information aims at verifying (if applicable) that the geographical data are correctly processed in the tool. 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)).

5.2.2 The parameters of geodetic reference systems and geographical projections must comply with reference geographical standards.

5.2.3 The transformation parameters between various reference systems or projection-based coordinates must also be verified against reference material. An alternative method to verify the correct transformation is to compare the coordinates of a set of representative given points known in two reference systems/projection systems with the coordinates processed through actual transformation in the tool. This process should be carried out for all the reference systems and projection systems that are used for procedure design.

5.2.4 Appendix A provides tables of transformations between several common geodetic reference systems and tables of conversion from WGS-84 geographical coordinates to common projection-based coordinates.

5.3 WGS-84 CALCULATIONS

5.3.1 The validity of WGS-84 geodetic calculations computed with the tool must be assessed (if applicable).

5.3.2 Geodetic calculations to be considered include at least the following :

- coordinates of a point defined by azimuth and distance from a known point;