ICAO RBIS TOD PROJECT

TERRAIN AND OBSTACLES DATA

TOD VERIFICATION AND VALIDATION PROCEDURE

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0. DOCUMENT ADMINISTRATION

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0.4. DOCUMENTS REFERENCES

- Annex 15: Aeronautical information Services
- Procedures for Air Navigation Services — Aeronautical and information Management (PANS-AIM, Doc 10066)
- Aeronautical and information Services (AIS) Manual (Doc 8126)
- Eurocontrol TOD manual

0.5. LIST OF TERMS AND DEFINITION

Accuracy. A degree of conformance between the estimated or measured value and the true value.

Confidence level. The probability that the true value of a parameter is within a certain interval around the estimate of its value. The interval is usually referred to as the accuracy of the estimate.

Data originator. The part of an organisation which performs measurements by a particular means and which then groups those measurements to represent an area of terrain or a set of obstacles.

Obstacle. All fixed (whether temporary or permanent) and mobile objects, or parts thereof, that are located on an area intended for the surface movement of aircraft or that extend above a defined surface intended to protect aircraft in flight.

Terrain. The surface of the Earth containing naturally occurring features such as mountains, hills, ridges, valleys, bodies of water, permanent ice and snow, excluding obstacles.

Traceability. Ability to trace the history, application or location of that which is under consideration.

Validation. Confirmation, through the provision of objective evidence, that the requirements for a specific intended use or application have been fulfilled.

Verification. Confirmation, through the provision of objective evidence that, specified requirements have been fulfilled.

0.6. CONTENTS

1. CONTEXT

Data validation and verification for terrain and obstacle data are important tasks in data processing which aim to check and maintain data quality.

Within the TOD context each participant in the data chain receives data from the previous participant, verifies the correct reception and each processing step and validates the data quality before passing the data to the next participant in the data chain.

Verification and validation activities do not generate data quality per se, but ensure that quality requirements are met and maintained, thereby ensuring the integrity of the data.

To provide evidence, the procedures for verification and validation shall be documented in the quality management system (QMS) and all verification and validation activities shall be logged in the metadata for traceability.

2. COLLECTION OF TERRAIN AND OBSTACLES DATA

The TOD collection is facilitated by the use of the Aeronautical Data Catalogue, (tables A1.6 and A1.8), which contains a common data description for the data elements and data quality requirements with sufficient metadata provided to facilitate its verification and validation.

When AIS receive TOD, it checks the metadata received from the originator and asks the following questions:

— Is the data coming from an authoritative source (i.e. is the originator of the data on the list of authorized originators)?
— Is the metadata complete and are the accompanying documents unambiguous and comprehensible?
— Have all applicable quality requirements, as specified in the formal arrangement (e.g. accuracy, resolution, integrity, format, etc.), been met?

Before further processing, TOD received from an originator is verified and validate to ensure it has not been corrupted during transfer.

All data received from sources shall, if possible, be validated and/or verified before entering the processing chain.

3. VERIFICATION AND VALIDATION PROCEDURES

3.1 VERIFICATION

All data collected or processed shall be verified to ensure its correctness before transmission to the next actor in the data chain. Suitable verification may take one, or more, of three approaches.

By verifying terrain and obstacle data, the AIS ensures that the output of the applied processes or actions still conforms to the specified data quality requirements without having introduced errors.

In the TOD context, the following verification techniques can be applied:

- Data integrity checks;
- Feedback;
- Independent redundancy;

  Update comparison.

3.1.1. DATA INTEGRITY CHECKS

Whenever data is entered manually, the data must be verified to ensure that no errors have been introduced. In this case the following verification procedures shall be applied

a) routine data requires single data entry that is checked at least once;
b) essential data requires the data entry to be independently checked at least once; and
c) critical data requires the data entry to be independently checked twice.

If terrain and obstacles data (TOD) elements of different integrity classification levels are processed together (e.g. routine data is processed together with essential data), then the higher integrity level should be used for selecting the appropriate verification.

When formatting TOD, the correct application of the data representation rules must be verified. In this case, the verification technique may be to conduct a visual check of the output.

The application of digital error detection mechanism like hash functions or cyclic redundancy checks (CRC) are applied to the data that provides a level of assurance against loss, modification or corruption of data.

3.1.2. FEEDBACK AND INDEPENDENT REDUNDANCY CHECKS

Feedback and independent redundancy checks can be used to verify correct execution of a data translation process (e.g. coordinate transformation or data extraction).

Feedback testing is defined as the comparison of a data set between its output and input state. So when geographical coordinates must be transformed, the correct application of the transformation formula should be verified using one of the following techniques:

a) reverse transformation of the output and comparison with the original coordinates;
b) independent calculations using another application or a recognised web-service of a geodetic institute; or
c) manual calculation.

Independent Redundancy testing involves processing the same data through two (or more) independent processors and comparing the data output of each process. The following verification techniques could be used:

a) Comparison of a sample of the data set points with samples from an independent measurement system. For obstacle data sets, this could involve re-measurement of a sample of the obstacle collection by GPS readings. The more samples that are checked, the higher the level of confidence in the quality of the data set.

b) Comparison of the obstacle data set with other existing data sets. For this verification method, the vertical and horizontal reference datum for the data sets should be taken into account and the data sets should be independent.
c) Reasonableness checks to ensure that the obstacle data set does not violate known properties of obstacles, e.g. obstacles have positive heights;
d) Comparison of the data set with independent measurements made during flight test

3.1.3. UPDATE COMPARISON

Updated data can be compared to its previous version. This comparison identified all data elements that have changed. The list of changed elements can then be compared to a similar list generated by the supplier. A problem can be detected if an element is identified as changed on one list and not on the other. This method can also be used to reduce the amount of data that is subjected to other forms of verification, concentrating on only those elements that have changed.

3.2. VALIDATION

The data quality requirements and in the Aeronautical Data Catalogue serve as reference for data validation.

By validating TOD, the AIS confirms and provides assurance that the quality requirements for the intended use are fulfilled. The users of the data rely on the validation performed by the AIS.

The purpose of validation is to ensure that the data meets the requirements or in other words that the data is fit for its intended use.

Data should be validated as early as possible in the data chain. The earlier non-compliances with the data product specification or the data quality requirements are discovered, the cheaper it is to correct the deficiencies.

Therefore, the obligation for data validation is a responsibility of the actors at every stage the data chain:

- At data origination;
- At data collection;
- At data product preparation.

3.2.1. VALIDATION AT DATA ORIGINATION

The data originator is the first actor in the data chain and is responsible for “creating” the data quality. The subsequent actors can only maintain the quality of the data but not increase it. Data validation at origination is therefore crucial for the quality of the data product reaching the user.

The originator of terrain or obstacle data is the only actor in the data chain who has access to the objects to be surveyed. Therefore, the data originator has to validate the measurements (coordinates, heights, extents), the object coding (recorded surface, obstacle type), other observed attributes (marking and lighting) and the completeness of the survey (have all obstacles in the area of interest being surveyed).

3.2.2. VALIDATION AT DATA COLLECTION

Data collected from the data originators has to be validated before further processing. With the validation at this stage it is ensured that the collected data complies with the quality requirements specified in the formal arrangements.

The main source of information for this validation is the metadata and survey report accompanying the collected data. The following checks should be done:

Accuracy:	Is the accuracy of the data indicated and does it meet the requirements?
Resolution:	Is the resolution commensurate with the accuracy? That means: is the data provided with enough digits not to jeopardise its accuracy?
Integrity:	Is there comprehensible evidence that the data has been processed according to the integrity classification (see traceability)?
Traceability:	Have all the relevant origination, translation and validation processes been documented by the data originator (Lineage information in the metadata)
Timeliness:	Is the effective period of the data elements defined?
Completeness:	Do the features (obstacles, terrain models) have all the required attributes? Does the metadata have all required information? Is there comprehensive evidence that the data originator has validated the data for completeness (e.g. that all the obstacles in the area of interest have been surveyed)?
Format:	Has the data been provided in the format specified in the formal arrangements?

3.2.3. PLAUSIBILITY CHECKS OF THE DATA

In addition to validating the data based on the methods described above, the following plausibility checks can be applied:

- Obstacle and terrain data can be validated by visualisation in a geographic information system. Topographic maps, orthophotos or satellite maps serve as the geographic reference.
- Obstacle data with elevation and height (above ground) attributes can be checked against digital terrain data. The terrain elevation at the foot-point of the obstacle should be identical (within tolerance) to the obstacle elevation minus its height above ground.

Obstacle data can also be checked against digital terrain data in a 3D-viewer. Erroneous obstacles are either sticking in the terrain or floating in the air.

3.2.4. VALIDATION AT DATA PRODUCT PREPARATION

Data sets generated at data collection are validated before they are provided or made available to the next intended user. Validation at this stage means checking that the data set complies with the relevant data product specification.

The validation of the data sets includes:

Completeness checks:	Are all the relevant obstacles included in the data set? Does the data set have no excessive data elements (e.g. obstacles that should not be in the data set)? Are all required feature properties part of the data set? Is all required metadata included with the data set?
Consistency checks:	The check is related to logical consistency, format consistency and conceptual consistency.

3.3. VERIFICATION AND VALIDATION BY SAMPLING

The purpose of sampling is to select a representative sub-set of the main data set. Hence, the sample size is reduced enough to perform a validation/verification task which is impossible to fully automate. Such tasks can be:

- Ground inspection;
- Additional independent survey;
- Manual verification of correctness of a value by checking it in the documentation. For example, if confidence level in the data set is 95%, then check for evidence that the provider actually committed to provide the data set with this confidence level;
- Other checks.

3.3.1. SAMPLING FOR ACCURACY ASSESSMENT

The goal of accuracy assessment is to determine if the value of an attribute is consistent with the universe of discourse (or at least, within the tolerances).

To build a representative sample, several methods can be used. It is proposed to use a stratified method based on obstacle collection surface. It appears to be the most relevant method for TOD.

P is the percentage which defines the size of the sample. This percentage can vary from 5% to 30%.

For each obstacle collection surface of the assessed data set, randomly choose P% of entries to create the sample. The sample will be P% of the original data set and each obstacle collection surface will be represented proportionally to its amount of entries.

This sample created can now be checked considering accuracy, thanks to ground inspections (checking obstacle type, marking, lighting etc.) and/or surveys (checking the accuracy of the coordinates). Those operations shall be independent from the first acquisition.

For checking the accuracy of the coordinates, the check-survey should be considered as the true value and therefore be significantly more accurate than the accuracy requirements.

3.3.2. SAMPLING FOR COMPLETENESS ASSESSMENT

Completeness assessment by sampling mainly focuses on omission of obstacles in an area survey. The sample is not built from the assessed data set, instead a representative sample area has to be defined for validating the completeness.

The location and size of the sample area or areas should be chosen based on obstacle collection surfaces and take into account the density of the area. To be representative it should include 5% to 30% of the obstacles of the complete survey.

It is advisable to put emphasis on areas where the ground is the most elevated (mountains, hills, etc.). For example, it is possible to configure the random selection to give more probability for elevated areas to be chosen.

The completeness check can be done by visual field inspection of the sample area. It should focus to identify all high thin objects (each technique will have limitation with very thin obstacles) and to integrate some elevation measurements as the top elevation of those objects may not always be properly measured.

The completeness check can also be done with an independent resurvey. If the latter is chosen then the completeness check can be combined with the accuracy assessment.

3.4. QUALITY ASSESSMENT OF EXISTING TERRAIN DATA

With regard to terrain data, it shall be ensure that for quantitative quality information related existing data:

- The post spacing (ground sampling distance) is not be greater than required;
- The stated horizontal and vertical accuracies are not be less than required;
- The geodetic reference system in which the data is available is be provided and, if needed, accurate transformation parameters to WGS-84/EGM-96 to ensure no degradation of the data quality.

For the evaluation of non-quantitative quality information related to existing data of the terrain data, the answer to the following questions will help to validate this data.

- How much information is available to support traceability? Is the lineage of the data documented ? Are the parties involved in data origination and processing known? If so, can they provide additional information to that already provided in the metadata? What is the date of original survey data? Is the area fully covered? How is the recorded surface (e.g. for DTM, are all vegetation or man-made features removed)? What is the representation of the elevation value in a cell (e.g. maximum, average)?
- The licensing should allow at least a limited distribution of the terrain data for aviation purposes;
- The liability of the data may not be stated in the metadata but must be evaluated.

At best, metadata will be available for the data sets and this can be used as a means of quality evaluation, without explicitly validating the data. Where metadata is not available or the quality of the metadata is questionable, sample testing should be performed. The spatial accuracy can be tested using existing geodetic control points. These control points should be evenly distributed over the entire data set and also reflect the different topographies in a region. Since the accuracy may be impacted by transformation and resampling, running these tests in the target reference system should be considered.

This initial assessment should clarify the gap between the requirements and the currently available terrain model. This gap analysis can then be used to determine if the gap can be closed by some kind of re-processing or post-processing and what the ensuing costs would be.

3.5. QUALITY ASSESSMENT OF EXISTING OBSTACLE DATA

The process for the validation of existing obstacle data is similar to that for terrain data. The following quality issues may have to be taken into account in the data migration:

- Data inconsistencies and ambiguities between different sources (charts) or between different AIPs (cross-border in Area 2);
- Geometric footprint (existing data is mainly of type “point” or "line" even if the footprint exceeds the threshold and requires polygon obstacle features);
- Spatial and thematic accuracy;
- Commission/omission of data:
  - entire features missing because of selection processes applied for cartographic purposes;
  - thematic information missing due to different application schema (more attributes to be provided according to the ICAO PANS-AIM schema);
- Different coordinate reference system.

Before the migration should be started with a careful analysis of the quality of a data sample is made in order to determine how many obstacles and which attributes are missing. In addition, when several charts are published for the same area, and especially when there are cross-border issues, an analysis is made to determine the inconsistencies between the different sources.

This analysis and assessment help to identify the quality deficiencies of existing data, to determine which processing steps must be taken to enable the publication of obstacle data or to annotate the limitation of use of the published information until resurveyed data is available.

3.6. OTHERS VALIDATION METHODS

3.6.1. COHERENCE WITH SPECIFICATIONS

Coherence with specifications consists of comparing data to its specifications. This method cannot completely validate the data, as there is the possibility that the data has an error that lies within the expected specifications.

3.6.2. SELF-COHERENCE

Self-coherence consists of comparing data within the data set itself and identifying inconsistencies.

This method cannot completely validate the data, as there is the possibility that data consistent in error. For example, it is possible from some data of the data set to compute data, which already exist in the data set and then compare computed data to existing data in the data set.

3.6.3. COHERENCE WITH EXOGENOUS DATA

Coherence with exogenous data consists of comparing two different data sets and identifying inconsistencies between values. This method cannot completely validate the data as there is the possibility that the different data sets include the same error. Independence of the data sets substantially improves the effectiveness of this type of validation.

Different data validation techniques can be used for different data items and/or parties in the scope of 'ADQ' requirements. Every time validation technique should be fit for purpose and sufficient to give the party the level of assurance that the data is checked as having a value that is fully applicable to the identity ascribed to the data element, or a set of data is checked as being acceptable for their intended use.

An assessment of the Terrain and obstacle Datasets shall be conducted by the AISP and evidence shall be obtained to achieve the level of assurance that these products meet the data quality requirements for Terrain and obstacle data.

3.7. ERRORS HANDLING

Whenever errors are detected during the verification or validation activities these errors must be recorded and corrected before proceeding to the next phase. Errors may be due to inconsistent data, missing data, corrupted data (or data not meeting quality requirements) or faulty processing.

An error may be detected while still within the aeronautical data process (e.g. by the final quality control check) or, once the error has already left the AIS, by a user using a published product or data set.

Every error should be analysed and possible root causes, once identified, eliminated by changing the procedure, providing additional training to the staff or by automating the entire process.

All errors, inconsistencies and anomalies detected in published essential TOD are to be notified immediately by the Authorised Source to all users via the promulgation of a NOTAM and resolved permanently as soon as possible thereafter.

When an error is detected, the appropriate action to be taken depends on different criteria such as:

- the criticality (the severity of the potential consequences) of the error;
- the cause of the error (error in the data or in the processing);
- the circumstances of the detected error (i.e. whether the error is detected before or after publication of the aeronautical information products and services); and
- the time required to fix the error.

When errors are detected, the following steps should be undertaken (see figure 1):

- log the error;
- analyse the error, i.e. has the error already been published, is it critical, is it a data error, is there a need to notify the originator?
- determine the root cause;

- apply corrective action(s), e.g. update the data processing system where the error was initiated;
- update the aeronautical information product which contains the error; and
- update and close the error log.

3.7.1. ERROR ANALYSIS

The following error categories are established:

- *critical error* implies that the error directly compromises the safety of air navigation, for example: the error could compromise aircraft clearance from terrain;
- *major error* implies information intended for communications or air navigation purposes is missing, ambiguous or difficult to interpret, and
- *minor error* implies the erroneous data has no operational impact, i.e. any instance of typographical, grammatical, printing or formatting deficiency which does not directly cause operational difficulties but does not meet expected standards.

During the analysis, the error tracking (see appendix 1) form must be used. AIS determine the root cause of the error, i.e. whether the data error has been introduced at origination or whether the error has been introduced during subsequent internal processing.

3.7.2. CORRECTIVE ACTION

Once error analysis is completed, corrective actions must be applied to the erroneous data.

If the corrective action cannot be completed within the available time before distribution, then the publication date and the effective date need to be postponed until the error can be corrected

If the TOD has already been published, and the error category determined it to be a critical error, the users must be informed as quickly as possible.

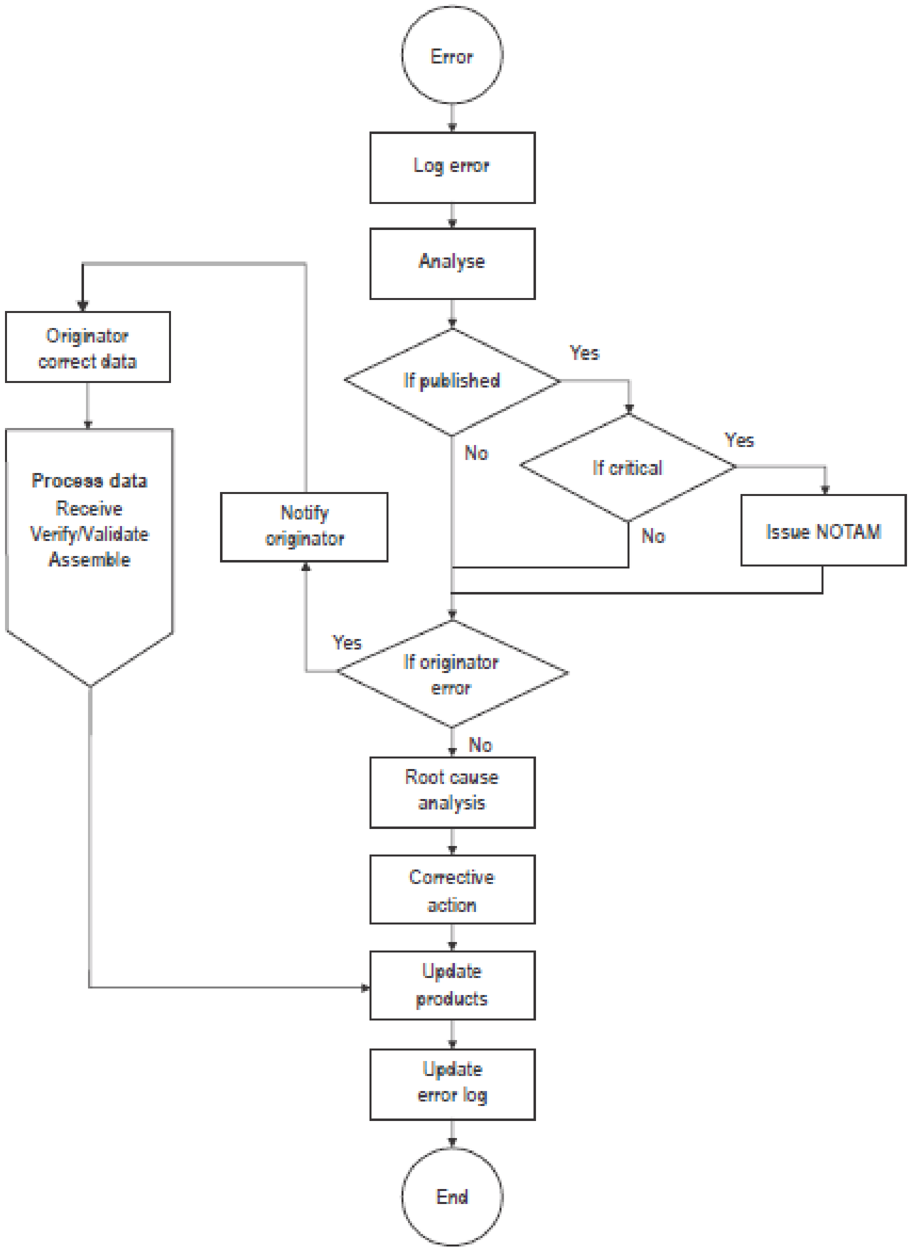

Figure 1: Error detection and reporting process

APPENDIX 1: ERROR TRACKING FORM

Reg. Nº	Description of error	Error categories	Root cause of the error	Correction action plan	Preventative action plan	Date	Actors
001/22							
002/22							
003/22							
004/22							