Smart Managing Aeronautical Data

Sabina Plăvicheanu[1], Florin Nache[2], Petre Iuliu Dragomir[3]

Received: April 2016 / Accepted: September 2016 / Published: December 2017

Abstract

This research study focuses on the individuality and complexity of aeronautical data, considering both acquisition and processing methods to be customized to this field. Aeronautical information is integrated into GIS environment that is designed for the needs of this industry, where standardization and interoperability are the key elements, data quality requirements are higher and accurate coordinates are essential for aeronautical safety. The goal is to design efficient database management systems, able to store, analyse, validate and manipulate spatial data, according to the applicable aeronautical regulations.

Keywords

Aeronautical data, GIS, Obstacle assessment, Interoperability

1. Introduction

In order to improve the accuracy and safety of air traffic in a coordinated and structured manner, each ICAO signatory country adheres to standardizing data exchange.

While meeting the international standards, some countries (e.g. United Kingdom, United States of America, United Arab Emirates, etc.) have issued their own modified versions of ICAO specifications to fulfill local conditions.

Two of the main international airports in Romania, Henri Coandă International Airport (LROP) and Aurel Vlaicu International Airport (LRBS), which are managed by Bucharest Airports National Company, have recently implemented eTOD (electronic Terrain and Obstacle Data) complying to ICAO requirements, providing precise and reliable digital information to underpin vital operations for Civil Aviation Authorities, airport authorities and airlines.

[1] PhD. Student, Eng. Sabina Plăvicheanu
Technical University of Civil Engineering of Bucharest, Faculty of Geodesy,Romania, E-mail: sabina.plavicheanu@gmail.com

[2] PhD. Student, Eng. Florin Nache
University of Bucharest, Faculty of Geology and Geophysics, Romania, E-mail: nacheflorin@yahoo.ro

[3] Prof. PhD. Eng. Petre Iuliu Dragomir
Technical University of Civil Engineering of Bucharest, Faculty of Geodesy,Romania, E-mail: petreiuliu.dragomir@gmail.com

eTOD includes geospatial data and metadata supported by common reference datum, stored in a database which is developed to guarantee an uniformity of norms and rules worldwide.
Henri Coandă International Airport located in Otopeni, 16.5 km north of Bucharest, serves as a base of operations on two parallel instrument runways 08L/26R and 08R/26L.
Aurel Vlaicu International Airport located in Băneasa district, Bucharest, no longer carries scheduled passenger traffic, as it has been converted into a business airport, which handles charter flights on 07/25 instrument runway.
Approaching the tasks of the project, organizational and technical issues were carefully considered. Since LRBS is situated 7 km away from LROP and their related eTOD coverage areas overlay significant part of Bucharest's urban area, data collection was not treated independently for each airport, but as a whole. Looking ahead to the big data to be dealt with, by means of volume and variety, the workflow structure had to be adapted from survey to data validation to satisfy the need for harmonizing data.
One key to good productivity and, in the end, the ability to present exact information is having options in accessing that data. This happens by asking the right question at the start: how will the data be used? Standardized information services indicate what a service provides, the structure at a logical level, the behavior, the performance and how the service can be accessed. Interoperable information exchange is specified through digital data services.

2. Materials and methods

Each aerodrome regulates its own operational needs, so data acquisition is performed accordingly. Aerial photogrammetric acquisition has been chosen for conducting this study. The techniques used will depend upon the terrain being modelled.
More sources of data combined increase the volume of data to be analysed. As different processing software return output results in different formats, data has to fit in the imposed structure to have control over the analysis.
When analysing data, it is important to know the coordinate reference system it belongs to, to what accuracy it is known and how, when and by whom it was acquired, to be able to consider a level of confidence. Datasets can then be validated using an independent check, showing how well they meet the criteria set forth in their specification.
Technically speaking, the geodatabase product is built with a particular data model in mind, although different models apply to different stages of the design process [1].

2.1. Database design

Designing the database structure starts with identifying its purpose and the requirements analysis. This has to be considered from every perspective.
The sequential steps used are shown below (Fig. 1).

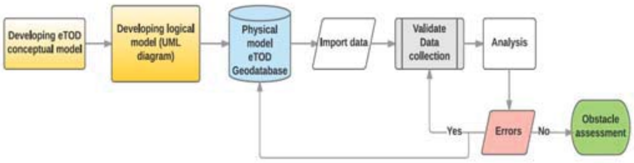

Fig. 1 Steps in creating data models

The architecture of the aeronautical management system has three levels of abstraction: the conceptual model, the logical model and the physical model.
Conceptualization is the initial phase of database design where by adapting user data to eTOD data, entities, their geometry, attributes and dependencies are identified.
The logical model converts the conceptual model by creating UML diagrams to explicitly describe entity relationships and process workflow. Good decision making is necessary for logical modeling, as it affects the performance of the database. The diagrams generated in this phase of the project are used to determine if the desideratum has been completely achieved.
The actual design of the database is done during physical modeling, following the delineated structure in the logical model.

2.2. 3D modeling

Modeling eTOD coverage areas implies polygonal 3D modeling of the protection surfaces set down by ICAO guidelines to designate the obstacle area boundaries.
Due to the large data volume and its variety, algorithms based on iterative processes are developed through mathematical modeling for efficient analysis.
There are various interpolation methods for surface modeling that take into account three-dimensional space layout, although the Delaunay triangulation method with linear interpolation for irregular network and the cubic spline interpolation method represented by the Voronoi diagram are to be noted.
TIN structures are used for high-precision modeling terrain datasets [2].
3D modeling for creating DTM over the area of interest must be performed considering the stringent accuracy and resolution set by eTOD guidelines and also the sampling intervals.

2.3. 3D Data management

How well a dataset is managed is an indicator of how reliably it meets the requisite. Geospatial data is increasingly used in dynamic environments [3] and interchanged, hence steps must be pondered so that its integrity is not affected

during several processes. A thorough analysis should be performed to determine the effect of errors on system integrity. Using architectural techniques such as system redundancy can increase data integrity.
Aeronautical data must be continuously maintained and updated. Features can only be added or deleted from a dataset, but not modified as traceability will be lost.
Automating certain processes significantly lowers the percentage of error occurring, both in data processing and in the analysis and manipulation phases.

2.4. Data quality

Aeronautical Data Quality (ADQ) is a comprehensive term as it stands for quality elements such as accuracy, resolution, integrity, traceability, timeliness, completeness and logical consistency. Information about the quality of available terrain and obstacle datasets is mandatory as a complete description of the data provided.
To ensure that the horizontal and vertical position contained in the datasets are fit for purpose, a quality control must be performed, showing how good the estimation is and how much it can be relied on. Any type or error may affect the confidence level of information, systematic errors and blunders having the biggest impact and should be eliminated before analysis [4].
Information about latest update or the effective date of data must be available as data collection contains temporary obstructions that may cease to be effective.

3. Results and discussions

To accomplish this project, a series of fundamental steps was followed, from data gathering, creating the eTOD geodatabase, developing methods to differentiate the spatial data into the four eTOD coverage areas and complex analysis for obstacle assessment.
Inconsistencies between data attributes and the geodatabase schema attributes are critical, some of them are brought to attention and examined.
When capturing data using either Airborne LiDAR or photogrammetric method, one major issue to face with is the geometry of small-diameter objects such as antennas, poles or pylons that in many cases is not correctly detected. Therefore, elevation and height for such obstructions must be verified and surveyed by traditional methods.
On the other hand, one relevant consideration is calculating height attribute as metadata for obstacles. Having the data acquired through photogrammetric methods, height can be derived from the difference between the top elevation of the obstacle and the ground elevation. With regard to the error propagation, this is accurate only if both are originating from the same survey. Uncertainties can occur when obstacles' heights are attained from different sources.
Moreover, for polygon features as buildings standing on a slope, height value cannot be determined with high accuracy, as it is not known whether that value is an average or a maximum.
Verification and validation (Fig.2) are steps to bear in mind before integrating data for eTOD analysis.

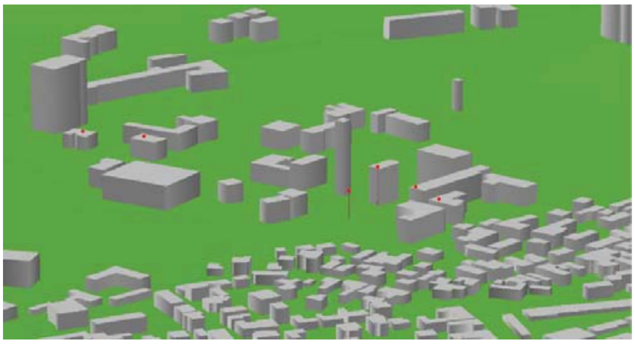

Fig. 2 Data validation with control points from terrestrial surveys (red points)

4. Conclusions

Acknowledging the importance of database design will help building better organized and more effective database systems. How models are created influences how they employ to satisfy the objective of the project.
eTOD deliverable forms the template for terrain and obstacle modeling database. All new obstacles created in the future can be added to the database to update the models.
It is imperative for any system that uses three-dimensional analysis to select the appropriate DTM/DSM in matter of accuracy and resolution.
The development of aeronautical management system ensures the quality of aeronautical data and also data exchange for sustainable growth.

References

[1] Panayotov, A., Georgiev, I., Georgiev, I. 2012. A Practical Approach for Airport Spatial Modeling. Proceedings of the 13th International Conference on Computer Systems and Technologies
[2] Chang, S.-W. 2016. A GIS Model for Analyzing Airspace Obstructions and Safety near Airports. Journal of Civil Engineering and Architecture, 553-562
[3] Ulubay, A., Altan, M. O. 2002. A Different Approach to the Spatial Data Integration. Symposium on Geospatial Theory, Processing and Applications
[4] Wang, C., Hu, Y., Tao, V. Identification and Risk Modeling of Airfield Obstructions for Aviation Safety Management