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**Agenda Item 6: Transition from AIS to AIM**

**Regional implementation of Electronic Terrain and Obstacle data (e-TOD)**

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**SUMMARY**

This working paper summarizes the ICAO requirements, data integrity and accuracies, source data collection methods, data management and maintenance and quality standards considerations in the implementation of certain electronic sets of Terrain and Obstacle data (eTOD) that are to be made available by November 12, 2015. The purpose of eTOD provisions is justified as supporting data for various PBN applications which can bring significant safety benefits for the international civil aviation. Also, in recognizing the challenges and complexities associated with an e-TOD Area 2 implementation for a State this paper also proposes to the Meeting analyze the feasibility of establish a Regional Cooperation Project to implement regionally this Standard.

**REFERENCE:**

Annex 15

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| ***ICAO Strategic Objectives:*** | *A - Safety*<br>*C - Environmental Protection and Sustainable Development of Air Transport* |

## 1 Electronic Terrain and Obstacle data

### 1.1 Background

1.1.1 Amendment 36 to ICAO Annex 15 introduced requirements for States to ensure that electronic sets of Terrain and Obstacle data (eTOD) are made available. The data shall be made accessible for four distinct coverage areas, ranging from the entire territory of the State (Area 1) through to the precision approach areas at an aerodrome (Area 4) with each area having differing data collection requirements. The new provisions in Annex 15 on the subject of electronic terrain and obstacle data are based on work done by ICAO with RTCA SC-193 and EUROCAE WG-44 industry groups as well as on comments received from States during the amendment process. It was acknowledged by ICAO, however, that the introduction of SARPS thru amendment 33 related to the provision of terrain and obstacle data was a challenge and, consequently, a new amendment 36 to ICAO Annex 15 was formally issued on the 1st April 2010 and was effective from 12th July 2010, becoming applicable on 18th November 2010. This Amendment offers significant cost savings over the original requirements introduced by Amendment 33.

1.1.2 The new provisions deal with the electronic terrain and obstacle data function, coverage, obstacle numerical requirements, content and structure of terrain and obstacle databases (defined as two separate databases), data product specifications for terrain and obstacle data and their availability. To be noted that the new ICAO SARPS in Chapter 10 "Electronic Terrain and Obstacle Data" to Annex 15 as published with amendment 36 and 37 have brought important changes regarding collection surfaces, new/updated data attributes as well as the implementation date for Area 2 implementation by member States. The standard establishes four basic sub areas for which terrain and obstacle data is required i.e. Area 2a, 2b, 2c and 2d which precise collection surfaces are to be found as textual and graphical description in Appendix 8 to Annex 15. The provision of a full Area 2 data set for all aerodromes are considered to be costly and, as a result, unlikely to be justifiable in many cases. Whilst the original intent of ICAO had been the provision of Area 2 data for all IFR aerodromes published in the State AIP, feed-back received from States indicated that this was not considered feasible or necessary. Consequently, the standard for the provision of full Area 2 had been revised with amendment 36, such that the provision of data Area 2a, 2b, 2c and 2d is now a Recommended Practice. Further, this Recommended Practice relates only to aerodromes "*regularly used by international civil aviation*". Finally, the standard requires that a limited set of eTOD data set i.e. sub-area 2a, and recommends sub-areas 2 (b,c,d) and 3, are made available from the specified date of 12th November 2015.

1.2 **Definition of coverage Area 2**

1.2.1 In order to satisfy the ICAO requirements for Annex 15 eTOD Area 2 the source data used to generate the terrain and obstacles needs to meet or exceed the minimum requirements for the following four coverage areas as defined in ICAO Annex 15 Chapter 10 Appendix 8. This also includes the need to meet the attribution and metadata requirements that will describe the features and data contained within the terrain and obstacle database. Below is a high-level overview of the requirements for Area 2.

1.3 **Area 2**

1.3.1 Terrain:

- Coverage: Terminal Control Area (10km buffer from ARP extending to the TMA boundary or 45km radius whichever is smaller, terrain penetrating the horizontal plane of 120m above lowest THR elevation).
- Accuracy Requirements: the horizontal accuracy is 5m (CE90) and 3m (LE90) for vertical with a 30m post spacing and a data precision of 0.1m
- Data Integrity Requirements: Essential level (assure corruption does not occur at any stage of the entire process and may include additional processes as needed to address potential risks in the overall system architecture to further assure data integrity at this level)
- Attribution: There are 23 attributes that are associated with the terrain data, with 3 of the attributes being optional.

1.3.2 Obstacles:

- Coverage: Terminal Control Area (conical surface extending 10km from the end of the runway and buffering Area 2a following the elevation of the runway profile extending to the TMA boundary or 45km radius whichever is smaller). This Coverage area is divided into 4 distinct sub areas (2a,b,c,d) with different collection requirements for each
- Minimum Collection Requirements: Obstacles are collected based on a sub area minimum height (3m or 15m) and whether they penetrate to the Area 2 obstacle limitation surface.

- Accuracy Requirements: the horizontal accuracy is 5m (CE90) and 3m (LE90) for vertical with a 30m post spacing and a data precision of 0.1m.
- Data Integrity Requirements: Essential level (assure corruption does not occur at any stage of the entire process and may include additional processes as needed to address potential risks in the overall system architecture to further assure data integrity at this level)
- Attribution: There are 25 attributes that are associated with the obstacle data, with 3 of the attributes being optional.

## 2 Terrain and obstacle data collection methods

2.1 There are many important factors that need to be taken into consideration during the source data acquisition planning phase. Since the ICAO Annex 15 Area 2 terrain and obstacle specifications state the accuracies and resolution required to satisfy the minimum requirement, there are multiple source data platforms that are able to meet the for each specified area. These platforms include satellite-based, aerial-based and ground-based systems, along with the availability of ancillary sources, such as States AIP and the internet.

2.2 Before the source data is acquired an organization needs to take into account the cost-effectiveness, acquisition methods, accuracy requirements, integrity and availability of the source data. If data already exists then it should be reviewed and verified to evaluate if it could be utilized within your eTOD program. One important factor that needs to be understood is that source data collection methods that are incorporated for an eTOD program Area 3 & 4, could technically be used for Area 1 or 2, but are usually cost prohibitive.

## 3 Data management & maintenance

3.1 Once the decision is made to implement an eTOD program, it will be critical to determine a functional management system with a primary focus on maintaining the data integrity and quality. This management system includes software, data formats and data transfer mechanisms. This management system should also include a strong technical relationship with the data originator and host organizations. The technical relationship should include data generation, technical support, training and data updates. A State's eTOD program must be comprehensive in nature to ensure Annex 15 compliance and the ability to maintain data quality and integrity throughout the lifecycle of the obstacle and terrain data.

## 4 Quality standards

4.1 The quality aspects of eTOD data include key elements that need to be addressed and adhered to during implementation of an eTOD management system. This includes CE/LE90 accuracy standards, along with maintaining "Essential" level data integrity. To help support these data quality standards for Annex 15 compliance, there is a need for application of ISO 9001 and DO200A processes and systems. It is important to identify the need for standardized processes and data traceability to ensure the data integrity throughout its lifecycle. In support for data integrity, implementation of a Circular Redundancy Cycle (CRC) data check needs to be implemented in order to provide functional support. CRC data checked should be a function that is applicable at both the generator and host level of data management.

## 5 Implementation of an eTOD Area 2 program

Implementing an eTOD Area 2 program requires significant planning and resources and coordination with internal organizations and with external industry partners. This planning and coordination must allow a state entity to create a robust data management and maintenance program while establishing processes for achieving the reoccurring quality standards required by ICAO's Annex 15.

The eTOD Area 2 implementation should be managed by each State as a national eTOD program supported by necessary resources, a high level framework and a detailed planning including priorities and timelines for the implementation of the program.

The implementation of an eTOD Area 2 program is a challenge for all concerned. It is also recognized that some of those who must be involved in the implementation process are not aware of the responsibilities that they might have and that only a small cross section of those affected were fully aware of the implications and the new responsibilities arising. Furthermore, as a result of the nature of the task and the new technologies and standards that are involved, it is underlined that many stakeholders require training to enable them to perform the tasks for which they are responsible.

States should adopt/follow a collaborative approach involving all concerned parties in the implementation of eTOD program and establish a multi-disciplinary team defining clearly the responsibilities and roles of the different Administrations within and outside the Civil Aviation Authority in the implementation process (AIS, Aerodromes, Military, National Geographic and Topographic Administrations/Agencies, etc.

### 5.1 Terrain and obstacle data collection methods

5.1.1 There are many important factors that need to be taken into consideration during the source data acquisition planning phase. Since the ICAO Area 1, 2, 3 & 4 terrain and obstacle specifications state the accuracies and resolution required to satisfy the minimum requirement, there are source data platforms that are recommended for each specified area. These platforms include satellite-based, aerial-based and ground-based systems, along with the availability of ancillary sources, such as States AIP and the internet. Before the source data is acquired an organization needs to take into account the cost-effectiveness, acquisition methods, accuracy requirements, data integrity and data availability of the source data. One important factor that needs to be understood is that source data collection methods that are incorporated for Area 3 & 4, could technically be used for Area 1 or 2, but are usually cost prohibitive. Below is a breakdown of the primary data platforms or repositories that enable collection of the essential eTOD data, which then allow the ICAO requirements to be met.

### 5.2 Satellite-based

Imagery: there are multiple commercial satellite vendors available today that have the capability to capture imagery in locations throughout the world using a multitude of satellite image sensor platforms. This imagery can be collected in the form of monoscopic (2-D) or stereoscopic (3-D) and either as color or black and white. Stereo imagery could be used as a primary source for terrain generation as well as obstacle collection. The standard satellite image product usually is delivered with 0.5m pixel resolution, 5m horizontal accuracy and a 3m vertical accuracy. Most sensors today are exceeding these values, which are providing customers with a higher quality product.

eTOD Application: The primary use for stereo imagery would be to generate terrain and obstacle data for Area 2. Mono Imagery could be used to generate obstacle data for Area 1 & 2 using 2-D measuring techniques.

Radar: there are a limited number of commercial satellite vendors that provide access to RADAR sensors. Radar sensors are primarily responsible for generating the world wide terrain datasets, such as Shuttle Radar Terrain Mission (SRTM) and Digital Terrain Elevation Data (DTED), which we use today. Most of these dataset are used in the form of Digital Elevation Models (DEM). Two sub products that are produced from DEM's include Digital Terrain Models (DTM) and Digital Surface Models (DSM). These datasets, when using at least a 5m posting, can achieve vertical accuracies of +/- 0.5m to +/- 3.0 m. It is important to understand that the accuracy the requirements or requests, greater the cost. (Remote Sensing for GIS Mangers, 214)

eTOD Application: The primary use for these datasets is the generation of terrain data for Area 1. A Radar satellite could produce terrain data with Area 2 accuracy requirements, but at an increase in cost.

5.3 **Aerial-based**

Imagery: there are multiple commercial vendors available today that have the capability to capture imagery in locations throughout the world using an aircraft platform. This imagery could be in the form of monoscopic or stereoscopic and either in color or black and white. Based on the aircraft's flying height and available ground control, the imagery's resolution and accuracy could vary, but would exceed the Area 3 & 4 requirements.

eTOD Application: Stereo aerial imagery is primarily used for Area 3 & 4 terrain and obstacle collection. Mono imagery, limited to 2-D collection methods, has applications in Area 2, 3 & 4 obstacle collection, with additional data processing.

LiDAR: LiDAR, which stands for Light Detection and Ranging, uses active remote sensing technology that measures the distance to, or other properties around, targets by illuminating the target with laser light and analyzing the backscatter. This data is used for generating highly accurate terrain data and allows you to collect obstacle features based on the resolution of the data collected. Accuracy of this data when flown from an aerial platform can exceed horizontal accuracies of 30cm and vertical accuracies of 20cm, which would exceed Area 3 & 4 requirements. (Remote Sensing for GIS Managers, 231)

eTOD Application: LiDAR data can be used for both obstacle and terrain generation for Area 3 & 4 if collected at an optimal resolution.

5.4 **Ground-based**

Ground Survey: includes all data that is collected using survey grade data collection instruments and the less accurate GPS systems. It also includes any technical process for height collection such as laser range finders or manual measurement devices.

eTOD Application: This data could be used as control data for runway extents and for the more rigorous Area 3 & 4. This control data could also be used for image control data applied to Area 2.

Field Data: includes any data, physical, cultural, etc. collected on-site or researched that provides additional characteristics for eTOD attribution or assists in the data collection process.

eTOD Application: this data collection method is primarily used in the analysis of Area 1 through 4.

5.5 **Ancillary**

State sources: includes Aeronautical Information Publications (AIP), archived data and cultural information used to extract terrain or obstacle data

eTOD Application: the primary use for state sources in the past has been for Area 1 terrain and obstacle data. If the data has proven accuracy attributed then it could be applied to Area 2, 3 or 4 once verified.

Internet sources: includes any internet based system that provides reliable data and information relating to terrain or obstacle data

eTOD Application: the primary use for internet sources would be to access archived terrain data (SRTM or DTED). There potential opportunities to access obstacle data, but they would need to be verified before use.

6 **Technical cooperation program**

6.1 As part of ICAO, a non-profit organization, TCB can offer its services under most favorable and cost-effective condition and guarantees strict neutrality, objectivity and transparency, as it does not represent any particular national or commercial interest, nor the interest of any donor in general. Its advice is therefore governed by objective technical and financial considerations.

7 **Suggested action:**

7.1 In recognizing the challenges and complexities associated with an e-TOD Area 2 program we would like to invite the States to analyze the possibility to develop a Regional Cooperation Project through ICAO Regional Office for implementing the e-TOD Area 2 Program.

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