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Agenda Item 2: Optimization of the ATS routes

The need for eTOD information from an industry perspective and ASTER GDEM terrain data suitability to fulfil ICAO Member States's Annex 15, Chapter 10 aviation requirements

(Presented by Jeppesen)

Summary

Amendment 33 to ICAO Annex 15 introduced requirements for States to ensure that electronic sets of Terrain and Obstacle data (eTOD) are made available. The purpose of eTOD provisions is justified as supporting data for various air navigation applications which can bring significant safety benefits for the international civil aviation.

This information paper summarizes the cockpit-based, ground-based and aerodrome mapping applications using sets of eTOD collected/recorded in accordance with all four coverage areas and it continues with description and benefits of specific navigation applications based on eTOD Area 1 & 4.

Finally, the information paper presents Jeppesen role as data integrator: on one side, its evolving eTOD-based applications fully support the end state of the ICAO Global ATM concept and, on the other side, recognizing the challenge for States of eTOD implementation, the set-up of eTOD Area 1 program for States CAA.

References

- ICAO Annex 15, Amendment 33

ICAO Strategic objectives	A – Safety C – Environmental Protection D – Efficiency

1. ELECTRONIC TERRAIN AND OBSTACLE DATA

1.1 BACKGROUND

Amendment 33 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.

These 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.

1.2 DEFINITION OF COVERAGE AREA 1, 2, 3 and 4

In order to satisfy identified user requirements for electronic terrain and obstacle data, while taking into account cost-effectiveness, acquisition methods and data availability, the data are to be provided according to the following four coverage areas definition:

1.2.1 AREA 1

a) Terrain:

- State territory excluding the geographical footprint of Area 3 & 4 and some portions of Area 2;
- Between 10km from ARP extending to the TMA boundary or 45km radius whichever is smaller, terrain not penetrating the horizontal plane of 120m above lowest THR elevation;
- Those portions of Area 2 where flight operations are prohibited;

b) Obstacles:

- Entire State territory all obstacles having minimum height of 100m AGL;
- Those portions of Area 2 where flight operations are prohibited;

1.2.2 AREA 2

a) Terrain:

- Within 10km from ARP;
- Between 10km from ARP extending to the TMA boundary or 45km radius whichever is smaller, terrain penetrating the horizontal plane of 120m above lowest THR elevation;

b) Obstacles:

- Conical surface whose origin is at the edges of the 180m wide rectangular area and at nearest runway elevation measured along the runway centreline, extending at 1.2% until reaches 120m above lowest runway elevation of all operational runways at the airport;
- Between 10km from ARP extending to the TMA boundary or 45km radius whichever is smaller, the horizontal plane of 120m above lowest THR elevation;

1.2.3 AREA 3

a) Terrain:

- Area adjacent to the movement area and extending from the edges of the runways up to 90m from runway centreline and for the rest of the movement area 50m from its edges;

b) Obstacles:

- Within same horizontal limits as above, all obstacles and terrain that raise higher than 0.5m above the horizontal plane passing through the nearest point of the movement area;

1.2.4 AREA 4

a) Terrain:

- Rectangular area of 60m each side of the extended runway centreline with the length of 900m extending from the runway threshold. This area is restricted to CAT II/III precision approach runways.

b) Obstacle:

- *Not required*;

2. TERRAIN AND OBSTACLE DATA APPLICATIONS

2.1 BACKGROUND

There is an emerging need for the development of digital aviation databases which are required to support the implementation of communications, navigation and surveillance/air traffic management (CNS/ATM) systems. During the past several years, there has been an increasing awareness within the aviation community that digital, computer-based avionics can be used to provide flight crew with additional information to support better, more balanced decisions.
Situational awareness is the term that best describes the ability of pilots to know what is going on in relationship to their aircraft and the external environment. The underlying philosophy is to make additional but relevant information available to pilots in order to assist them in their decision-making process. At the heart of a cockpit-centred situational awareness architecture is an advanced data management computer system. Beside the functions provided by existing avionics systems to fly the aircraft and to select optimized flight tracks as prescribed by procedure designers, the advanced CNS on-board system can support thru digital aviation databases a variety of new cockpit-based operational applications.
The “core” aviation databases include navigation, terrain, obstacles, aerodrome maps, airspace, and noise abatement procedures. Additional supportive aviation databases may also need to be developed and standardized in the future.

2.2 NAVIGATION APPLICATIONS USING TERRAIN & OBSTACLE DATA

Significant safety benefits for international civil aviation will be provided by in-flight and ground based applications that rely on quality electronic terrain and obstacle data. Terrain and obstacle databases can sustain two-dimensional (2-D), three-dimensional (3-D) and four-dimensional (4-D) predictive Controlled Flight into Terrain (CFIT) prevention systems as well as Approach and Landing Accident Reduction (ALAR) systems.
Sets of electronic terrain and obstacle data used in combination with relevant aeronautical data shall support the following air navigation applications:

2.2.1 COCKPIT-BASED APPLICATIONS

- Ground Proximity Warning System (GPWS) with forward looking terrain avoidance function;
- En-route “drift-down” procedures;
- En-route emergency landing location selection and,
- Synthetic vision;

2.2.2 GROUND-BASED OR GROUND-USED APPLICATIONS

- Minimum Safe Altitude Warning (MSAW) system;
- Instrument procedure design (including curved i.e. RF leg based approach procedures);

- Contingency procedure analysis (one-engine inoperative departure climb profile, etc);
- Flight simulator and,
- Aeronautical chart production.

2.2.3 AERODROME MAPPING DATA APPLICATIONS

Based on the availability of a standardized aerodrome mapping data set, a wide variety of applications can be envisioned. Note that several of the applications listed below can be used by multiple user classes e.g. pilots, Air Traffic Controllers, airline, Cargo, Business/General aviation, vehicle operators, etc:

- Map display information;
- Taxi guidance display information;
- Surveillance and conflict/runway incursion detection/alerting;
- Route/Hold-short portrayal and deviation detection/alerting;
- Advanced Surface Movement Guidance and Control System (A-SMGCS);
- Portrayal of D-ATIS information;
- D-NOTAMs with aeronautical data overlays;

3. FUNCTIONS OF eTOD AREA 1 AND 4

From the diversity of cockpit and ground-based set of applications where terrain and obstacle data play a significant role and which are listed in paragraph 2 above, this information paper will now continue to emphasize the respective functions supported by eTOD datasets collected and recorded in databases in accordance with coverage Area 1 and 4. According to ICAO Annex 15, paragraph 10.6 '*Availability*' member States looking for compliance with Chapter 10, Annex 15 requirements shall ensure that terrain Area 4 and terrain & obstacle Area 1 data are made available already as of 20 November 2008.

3.1 eTOD AREA 1 APPLICATIONS

3.1.1 TERRAIN AWARENESS AND WARNING SYSTEM (TAWS)

Ground Proximity Warning System (GPWS) technology with forward-looking capabilities provides flight crew with information of impending dangerous terrain and obstacles. This will result in earlier alerts and more time to take appropriate corrective action. New multifunction displays are merging terrain and obstacle databases, aircraft GNSS and Flight Management System sensor data.
Many qualified terrain warning systems use digitized terrain data intended for advisory use only since these data sets are not certified for navigation use as they lack stringent quality requirements (integrity).
Consequently, there is a significant safety benefit made possible by developing a comprehensive terrain and obstacle database.

3.1.2 MINIMUM SAFE ALTITUDE WARNING (MSAW) SYSTEM

MSAW systems use ground-based radar to monitor the flight paths of aircraft equipped with encoding transponders to ensure adequate terrain and obstacle separation. The alerting function is accomplished by comparing the flight paths with a three-dimensional grid map stored in the ground-based radar system. If a potentially unsafe condition is detected, the controller will alert the pilot by radio. This operational application is a flight critical safety application as air traffic relies on this data to provide flight crews with guidance pertaining to safe terrain and obstacle avoidance. Consequently, comprehensive terrain and obstacles data sets of higher accuracy in the aerodrome vicinity may provide increased protection against approach and landing accidents and CFIT.

3.1.3 EN-ROUTE 'DRIFT-DOWN' PROCEDURES

As aviation moves forward to use Area Navigation (RNAV), with point-to-point direct routings predicated on navigation systems, more aircraft will likely fly off-airways. Many of these routes will overfly mountainous terrain (for example, over the Alps), or areas such as the Greenland Ice Cap.
Occasional re-routings take commercial aircraft on routes where a one-engine inoperative "drift-down" may require the aircraft to descend over mountainous terrain. In some situations, the one-engine inoperative cruise flight may be performance limited such that the aircraft is unable to sustain flight above Minimum Obstacle Clearance Altitude (MOCA). Consequently, without any outside help, pilots need to quickly and accurately calculate their best "escape" route to avoid high terrain and/or to maintain the necessary terrain and obstacle clearance. Therefore, this operational application has both a safety as well as an operational component.
Note: Although the requirements related to these procedures are provided in ICAO Annex 6 '*Operations of Aircraft'* - Part I, there is no association with the name "drift-down" as indicated in the Annex 15, Chapter 10, paragraph 10.1.

3.1.4 EN-ROUTE EMERGENCY LANDING LOCATION SELECTION

During an in-flight emergency, especially in general aviation operations, selection of an acceptable emergency landing site can often mean the difference between an aircraft sustaining only minor or no damage, versus suffering catastrophic damage. The risks are great when an aircraft must land immediately for any reason when flying at night or over unfamiliar territory. Under such circumstances, a high resolution, digital image, containing vegetation and cultural features, overlaid onto a terrain and obstacle database could assist pilots in identifying the safest location for a forced, emergency landing.

3.1.5 AERONAUTICAL CHART PRODUCTION

For pilots, a graphical portrayal of all aeronautical, cultural and topographic information generally specified for all type of charts by Annex 4 '*Aeronautical Charts*', is essential to safe and efficient navigation. Currently, this graphical portrayal is mostly provided to flight crews by way of paper charts. Alternatively, chart images can be portrayed on electronic displays of a flight deck. Electronic chart displays or electronic data-driven charts distributed via digital media or world-wide web connectivity respectively are the most appropriate solutions to enable flight crews to execute, in a convenient and timely manner, route planning, route monitoring and navigation.
Consequently, the usage of terrain and obstacle dataset satisfying Area 1 numerical requirements for generating the topographic layer (including possible contour generation capability) will significantly enhance the chart display for following ICAO Annex 4 type of charts: En-route Chart, Area Chart, Aeronautical Chart 1: 500000, Aeronautical Navigation Chart – Small Scale, Plotting Chart and Radar Minimum Altitude Chart.

3.2 eTOD AREA 4 APPLICATIONS

The Annex 15 definition for Area 4 terrain intents to support the high demanding operational requirements (flare profile, rate of descent, etc) for CAT II/III approaches in terms of characteristics of the pre-threshold terrain areas. The Precision Approach Terrain Chart (PATC) is the current graphical depiction mean by which State authorities provide to operators information necessary to perform height determination during precision approaches. The area covered by PATC matches exactly eTOD Area 4, however Annex 4 requires that within PATC area all elevations (terrain and objects) that differ with more than 3m (10ft) from the runway centreline profile shall be indicated.

Note: Although Annex 14 '*Aerodrome Design and Operations*' – Vol. I recommends establishment of a Radio Altimeter Operating area located in the pre-threshold area of a precision approach runway in order to accommodate aeroplanes making auto-coupled approaches and automatic landings, the length of the area i.e. at least 300m is not matching Area 4 longitudinal profile of 900m.

4. JEPPESEN PERSPECTIVE TOWARDS ICAO eTOD BENEFITS

4.1 JEPPESEN AS eTOD USER

For several years, Jeppesen has been doing considerable research and development work on collection, management, systems interfaces and display of terrain and obstacle information. Starting with the basic terrain data provided by the Shuttle Radar Topography Mission (SRTM), Jeppesen has been significantly augmented the quality of the SRTM datasets by applying sound methods, intelligent mathematical algorithms as well as other datasets with very high accuracy. The final result was the generation of a worldwide terrain envelopes databases with designated confidence levels of 10^{-3} (routine), 10^{-5} (essential) and 10^{-8} (critical) – called TerrainScape Level 1, 2 and 3 respectively.
Furthermore, Jeppesen efforts have been focused on creation of a single-source geo-spatial data repository of terrain, terrain high-points and man-made obstacles in order to ensure that all chart images (En-route High and/or Low, Terminal and VFR/GPS 1:500000 charts) utilize a single common terrain source of the highest quality with known quality characteristics. In parallel, we are concentrating our development efforts on the data that air-framers and aircraft operators require to support new on-board systems designed <u>to enhance situational awareness in the air and on the airport surfaces</u> e.g. data-driven electronic charts, Airport Mapping (AMDB), Electronic Flight Bag (EFB), Airspace and Procedure Design, Opsdata analysis, TAWS/MSAW & Flight Simulation (Terrain + Navdata ARINC 424), Synthetic Vision System (SVS) displays, etc.
Practically, our evolving navigation applications where eTOD information is an important product component will continue to fully support the end state of the ICAO Global ATM concept.

4.2 JEPPESEN'S AREA 1 TERRAIN AND OBSTACLE DATA PROGRAM

Jeppesen recognizes that the terrain and obstacle requirements of ICAO Annex 15, Chapter 10 challenge many Civil Aviation Authorities (CAA) and Air Navigation Service Providers (ANSP) around the world.
Also, Jeppesen understands that certain States may not have processes established to deliver eTOD information to other users or may wish to outsource this responsibility.
Therefore, we have established processes, in cooperation with States that contract with Jeppesen, to maintain a State's Area 1 terrain and/or obstacle database and deliver it as required. It should be noted that our Terrain Area 1 data model has resolved the issues in relation to cross-border harmonisation as we have consistently applied same DO-200A/ED-76A quality-driven processes.

Finally, it can be mentioned that Jeppesen eTOD service for CAAs and ANSPs offers the possibility for States to notify compliance with Chapter 10 in its AIP (see also reference in GEN 1.7 '*Differences from ICAO SARPS'*).

— END —