Electronic Terrain and Obstacle Data

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ETOD intended uses

- New cockpit-based systems
- Emergency procedures
- Situational awareness and terrain warning
- Instrument and contingency procedure design
- Flight simulators
- Aerodrome surface movement guidance and control
- Chart and database production
Cockpit-based situational awareness systems

Diagram showing the relationship between CNS (Communications, Navigation, Surveillance) and the Computer Based System, which in turn feeds into the Display and the Aviation Databases (ADB).
En-route “Drift-Down Procedures”

• As aviation moves forward to use RNAV, with point-to-point direct routings predicated on navigation systems with specified RNP, more aircraft will likely fly off-airways
• Many of these routes will overfly mountainous terrain
• In the event of engine out situations 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
En-route emergency landing

• selection of an acceptable emergency landing site can often mean the difference between an aircraft sustaining only minor or no damage, versus sustaining catastrophic damage

• 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.
Synthetic vision

- Synthetic vision systems are expected to emulate day visual flight operations at night and in limited visibility conditions
- Virtual visual environment
- Database integrity of paramount importance
- A possible use of eTOD - may require additional data and a higher resolution of data
- Benefits: Reduced risk of CFIT, aerodrome runway incursion, improved pilot situational awareness, improvement in unusual attitude/upset recovery, improved compliance with air traffic clearances and instructions.
Minimum safe altitude warning (MSAW) system

- MSAW works by having the ground-based radar system monitor the flight paths of aircraft equipped with encoding transponders to ensure adequate terrain and obstacle separation. This is accomplished by comparing the flight paths with a three-dimensional grid map stored in the ground-based radar system.
- At an MSAW alarm the controller warns pilot
- Last line of defence “safety net” in conjunction with terminal area surveillance radar
Instrument procedure design

• Procedures design include airways, standard instrument departures and arrivals, feeder routes, instrument approach and missed approach procedures and circling approach procedures

• Procedure design specialists use data describing both man-made and natural (terrain) obstacles and apply obstacle clearance criteria to calculate minimum altitudes for each procedure segment

• The minimum altitudes published in instrument procedures ensure that aircraft flown in instrument flight conditions do not impact the ground or known obstacles
Contingency procedures

- Aircraft operators are required to follow established departure and arrival procedures approved by the civil aviation authorities that are calculated on all-engine operational condition.
- However, Annex 6 provides aircraft operators are responsible for performing take-off analysis and determinations of contingency procedures in the case of emergency to ensure safe take-off (departures) and missed approach procedures for each aircraft type in their fleet flying at a specific aerodrome.
- Now appropriate data is often not available
- Digital data supports Annex 4 Aerodrome Terrain and Obstacle Chart – ICAO (Electronic)
Flight simulators

- Ground-based flight simulators would provide flight crews with a graphical “virtual reality” portrayal of the geographic areas containing terrain and obstacle data collected in an terminal airspace.

- Flight crews could become familiar with terrain and obstacles in terminal airspace by using simulations with enhanced databases and they can use simulators to train in order to maintain or improve proficiency at the specific terminal and aerodrome.
Aerodrome surface movement guidance and control

- Area 3 data and standardised aerodrome mapping database supports objectives of ICAO A-SMGCS Manual (Doc 9730)
  - Aerodrome situational awareness
  - Improved guidance and procedures regardless of visibility, traffic density, and aerodrome layout
  - Conflict prediction/detection, analysis and resolution
Cockpit display of aerodrome surface traffic
Map display with traffic and route information
Supports chart and database production

- Through GIS based chart production eTOD databases could support many of the chart products required by Annex 4
- Database updates are centralised rather than structured on individual aeronautical charts
- May support other types of charting/uses within the State – cost sharing?
- Support for future digital products
Example of an electronic chart information display
eTOD Definitions

- Total of 23 definitions related to eTOD
- eTOD definitions could be grouped into terrain, obstacles, datum and data product specification related subjects
- See Annex 15, Chapter 2
Terrain Definition

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

- forest
- field
- tree
- mountain
- smoke
- stack
- building

= canopy = bare earth = in between (e.g., first reflective surface)
Terrain Definitions

- **Bare Earth**: surface of the Earth including bodies of water and permanent ice and snow and excluding vegetations and man-made objects (culture)
- **Canopy**: bare Earth supplemented by vegetation height
- **Culture**: all man-made features constructed on the surface of the Earth, such as cities, railways and canals
Terrain Definitions

- **Relief**: the inequalities in elevation of the surface of the Earth represented on aeronautical charts by contours, hypsometric tints shading or spot elevations

- **Post spacing**: angular or linear distance between two adjacent elevation points
Digital Elevation Model (DEM)

Representation of terrain surface by continuous elevation values at all intersections of a defined grid, referenced to common datum
DEM and Post Spacing
Obstacle Definitions

- **Obstacle**: all fixed (whether temporary or permanent) and mobile objects, or parts thereof, that are:
  - a) located on an area intended for the surface movement of aircraft; or
  - b) extend above a defined surface intended to protect aircraft in flight; or
  - c) stand outside those defined surfaces and have been assessed as being a hazard to air navigation.

- **Obstacle/terrain data collection surface**: a defined surface intended for the purpose of collection obstacle/terrain data
ETOD Annex 15 Amendment 33

Area 1 - Standard
• Entire state territory

Area 2 - Standard
• All IFR aerodromes
• Area coverage extends to TMA or 45 KM (whichever less)
• Required data collection in accordance with Appendix 8

Area 3 - Standard
• All IFR aerodromes
• Within 90m of runway centreline and otherwise within 50m from all movement area edges

Area 4 - Standard
• Precision approach runways category II and III and information required for radio altimeter use
• 60m either side of runway centreline and 90m from runway threshold
Area 1 - Standard
  • Entire state territory *(no change)*

Area 2 – Revised coverage areas- Now divided into Areas 2a,2b,2c,2d
  **Reduced Standard 10.1.5** States essentially provide the information they were providing in the AIP before Amendment 33, however provide it in electronic form according to Chapter 10. Aerodromes regularly used by international civil aviation *(Δ from “All IFR aerodromes”)*

  **New Recommendation 10.1.6**
  • Required data in accordance with revised Appendix 8 *(considerable cost reduction)*
  • *(Δ from 18 November 2010, 12 November 2015)*

Area 3 – **Recommended Practice (Δ from Standard)**
  • Recommended at aerodromes regularly used by international civil aviation

Area 4 – Standard *(no significant change)*
  • Precision approach runways category II and III and information required for radio altimeter use
  • 60m either side of runway centreline and 90m from Runway threshold
  • *(RP) length to be extended not exceeding 2000m for mountainous or significant terrain. *(added note to align with Annex 4 PATC)*
Changes to Area 2 coverage

Amendment 33

Amendment 36
Reduced Standard and extended applicability date

• 10.1.5 From **12 November 2015**, at aerodromes regularly used by international civil aviation, electronic terrain and obstacle data **shall** be provided for:
  • a) Area 2a, for those obstacles that penetrate the relevant obstacle data collection surface specified in Appendix 8;
  • b) penetrations of the take-off flight path area obstacle identification surfaces; and
  • c) penetrations of the aerodrome obstacle limitation surfaces.
• **Note.**— **Take-off flight path area obstacle identification surfaces are specified in Annex 4, 3.8.2.1. Aerodrome obstacle limitation surfaces are specified in Annex 14, Volume 1, Chapter 4.**

• **NEW RECOMMENDATION**
• 10.1.6 **Recommendation.**— At aerodromes regularly used by international civil aviation, electronic terrain and obstacle data **should** be provided for Areas 2b, 2c and 2d for obstacles and terrain that penetrate the relevant obstacle data collection surface specified in Appendix 8, except that data need not be collected for obstacles less than a height of 3 m above the ground in Area 2b and less than 15 m above the ground in Area 2c.
Coverage Areas 1 and 2

- Area 1: the entire territory of a State;
- Area 2: within the vicinity of an aerodrome, sub-divided as follows;
  - Area 2a: a rectangular area around a runway that comprises the runway strip plus any clearway that exists.
  - Area 2b: an area extending from the ends of Area 2a in the direction of departure, with a length of 10 km and a splay of 15% to each side;
  - Area 2c: an area extending outside Area 2a and Area 2b at a distance of not more than 10 km from the boundary of Area 2a; and
  - Area 2d: an area outside the Areas 2a, 2b and 2c up to a distance of 45 km from the aerodrome reference point, or to an existing TMA boundary, whichever is nearest.
Coverage area 3

- Area 3: The area bordering an aerodrome movement area that extends horizontally from the edge of a runway to 90 m from the runway centre line and 50 m from the edge of all other parts of the aerodrome movement area.
**Coverage area 4**

- Area 4: The area extending 900 m prior to the runway threshold and 60 m each side of the extended runway centre line in the direction of the approach on a precision approach runway, Category II or III.
Terrain data collection surfaces — Area 1 and Area 2
Terrain data collection surfaces

1. Within the area covered by a 10-km radius from the ARP, terrain data shall comply with the Area 2 numerical requirements.

2. In the area between 10 km and the TMA boundary or 45-km radius (whichever is smaller), data on terrain that penetrates the horizontal plane 120 m above the lowest runway elevation shall comply with the Area 2 numerical requirements.
3. In the area between 10 km and the TMA boundary or 45-km radius (whichever is smaller), data on terrain that does not penetrate the horizontal plane 120 m above the lowest runway elevation shall comply with the Area 1 numerical requirements.
Terrain data coverage areas

4. In those portions of Area 2 where flight operations are prohibited due to very high terrain or other local restrictions and/or regulations, terrain data shall comply with the Area 1 numerical requirements.
Obstacle data collection surfaces — Area 1 and Area 2
Obstacle data collection surfaces — Area 1

- Area 1: Entire State territory
- Data on every obstacle within Area 1 whose height above the ground is 100 m or higher shall be collected and recorded in the database in accordance with the Area 1 numerical requirements.
- Coincides with WAC obstacle requirements
- Numerical requirements are specified in Annex 15, Table A8-2.
Obstacle data collection surfaces — Area 2

- a) Area 2a: a rectangular area around a runway that comprises the runway strip plus any clearway that exists. The Area 2a obstacle collection surface shall have height of 3 m above the nearest runway elevation measured along the runway centre line, and for those portions related to a clearway, if one exists, at the elevation of the nearest runway end;

- b) Area 2b: an area extending from the ends of Area 2a in the direction of departure, with a length of 10 km and a splay of 15% to each side. The Area 2b collection surface has a 1.2% slope extending from the ends of Area 2a at the elevation of the runway end in the direction of departure, with a length of 10 km and a splay of 15% to each side;
Obstacle data collection surfaces — Area 2

- c) Area 2c: an area extending outside Area 2a and Area 2b at a distance of not more than 10 km from the boundary of Area 2a.
- The Area 2c collection surface has a 1.2% slope extending outside Area 2a and Area 2b at a distance of not more than 10 km from the boundary of Area 2a.
- The initial elevation of Area 2c shall be the elevation of the point of Area 2a at which it commences;
d) Area 2d: an area outside the Areas 2a, 2b and 2c up to a distance of 45 km from the aerodrome reference point, or to an existing TMA boundary, whichever is nearest.

The Area 2d obstacle collection surface has a height of 100 m above ground.
Obstacle data collection surfaces — Area 2

- In those portions of Area 2 where flight operations are prohibited due to very high terrain or other local restrictions and/or regulations, obstacle data shall be collected and recorded in accordance with the Area 1 requirements.
• 10.2.1 A terrain data set shall contain digital sets of data representing terrain surface in the form of continuous elevation values at all intersections (points) of a defined grid, referenced to common datum. A terrain grid shall be angular or linear and shall be of regular or irregular shape.

• Electronic terrain data for each area shall conform to the applicable numerical requirements in Appendix 8, Table 8A-1.
• 10.3.1 Obstacle data shall comprise the digital representation of the vertical and horizontal extent of the obstacle.
• Obstacles shall not be included in terrain data sets.
• Obstacle data elements are features that shall be represented in the data sets by points, lines or polygons.
• 10.3.2 In an obstacle data set, all defined obstacle feature types shall be provided and each of them shall be described according to the list of mandatory attributes provided in Appendix 8, Table A8-4.
Data Product Specifications

• **Data product**: dataset or dataset series that conforms to a data product specification
• **Dataset**: identifiable collection of data
• **Dataset series**: collection of datasets sharing the same product specification
• **Data product specification**: detailed description of a dataset or dataset series together with additional information that enables it to be created, supplied to and used by another party
• **Metadata**: data about data
• **Portrayal**: presentation of information to humans
10.4.1 To allow and support the interchange and use of sets of electronic terrain and obstacle data among different data providers and data users, the ISO 19100 series of standards for geographic information shall be used as a general data modelling framework.
Terrain and obstacle data product specifications

• Data product specification (DPS) based on ISO 19131, contains comprehensive statement of terrain/obstacle data set
• Used to evaluate usefulness of a data set against one specific application
• DPS contains an overview, specification scope, identification, reference system, data content and structure, quality, capture, maintenance, portrayal, product delivery, metadata and any additional information
## Terrain data numerical requirements

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### Table A8-2. Obstacle data numerical requirements

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ETOD Manual

• Under development by EUROCONTROL TOD working group
• First draft out for comment
• Coordination with ICAO AIS-AIMSG
• Expected availability mid 2011
Questions?