ICAO RBIS TOD PROJECT

TERRAIN AND OBSTACLES DATA

GUIDANCE FOR TOD IMPLEMENTATION TEMPLATE

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0. DOCUMENT ADMINISTRATION

0.1. APPROVAL PAGE

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0.2. LIST OF EFFECTIVE PAGES

List of Effective Pages	
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0.3. RECORD OF AMENDMENTS AND CORRIGENDA

Record of amendments			
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0.4. DOCUMENTS REFERENCES

- ICAO Annex 15 – Aeronautical Information Services
- ICAO Annex 4 – Aeronautical Charts
- ICAO Annex 14– Aerodromes
- ICAO Doc 9674 – World Geodetic System – 1984 Manual
- ICAO Doc 9881 – Guidelines for Electronic Terrain, Obstacle and Aerodrome Mapping Information
- ICAO Doc 10066 – Procedures for Air Navigation Services — Aeronautical Information Management
- ICAO Doc 8126: Aeronautical Information Services Manual
- EUROCONTROL Terrain and Obstacle Data Manual
- EUROCONTROL Guidelines for harmonised AIP publication and data set provision
- EUROCONTROL Specification for the Origination of Aeronautical Data

0.5. LISTE OF TERMS AND DEFINITION

Aerodrome. A defined area on land or water (including any buildings, installations and equipment) intended to be used either wholly or in part for the arrival, departure and surface movement of aircraft.

Bare Earth. Surface of the Earth including bodies of water and permanent ice and snow, and excluding vegetation and manmade objects.

Calendar. Discrete temporal reference system that provides the basis for defining temporal position to a resolution of one day (ISO 19108*).

Canopy. Bare Earth supplemented by vegetation height.

Confidence level. The probability that the true value of a parameter is within a certain interval around the estimate of its value.

Data product specification. Detailed description of a data set or data set series together with additional information that will enable it to be created, supplied to and used by another party (ISO 19131*).

Data quality. A degree or level of confidence that the data provided meet the requirements of the data user in terms of accuracy, resolution, integrity (or equivalent assurance level), traceability, timeliness, completeness and format.

Data Set. A collection of data compliant with ISO 19101

Datum. Any quantity or set of quantities that may serve as a reference or basis for the calculation of other quantities (ISO 19104*).

Feature attribute. Characteristic of a feature (ISO 19101*).

Feature type. Class of real world phenomena with common properties (ISO 19110*).

Feature. Abstraction of real world phenomena (ISO 19101*).

Geoid. The equipotential surface in the gravity field of the Earth which coincides with the undisturbed mean sea level (MSL) extended continuously through the continents.

Gregorian calendar. Calendar in general use; first introduced in 1582 to define a year that more closely approximates the tropical year than the Julian calendar (ISO 19108*).

Height. The vertical distance of a level, point or an object considered as a point, measured from a specific datum.

Heliport. An aerodrome or a defined area on a structure intended to be used wholly or in part for the arrival, departure and surface movement of helicopters.

Integrity classification (aeronautical data). Classification based upon the potential risk resulting from the use of corrupted data. Aeronautical data is classified as:

a) routine data: there is a very low probability when using corrupted routine data that the continued safe flight and landing of an aircraft would be severely at risk with the potential for catastrophe;

b) essential data: there is a low probability when using corrupted essential data that the continued safe flight and landing of an aircraft would be severely at risk with the potential for catastrophe; and

c) critical data: there is a high probability when using corrupted critical data that the continued safe flight and landing of an aircraft would be severely at risk with the potential for catastrophe

Metadata. Data about data (ISO 19115*).

Movement area. That part of an aerodrome to be used for the take-off, landing and taxiing of aircraft, consisting of the manoeuvring area and the apron

Obstacle/terrain data collection surface. A defined surface intended for the purpose of collecting obstacle/terrain data.

Origination (aeronautical data or aeronautical information). The creation of the value associated with new data or information or the modification of the value of existing data or information.

Originator (aeronautical data or aeronautical information). An entity that is accountable for data or information origination and/or from which the AIS organization receives aeronautical data and aeronautical information.

Post spacing. Angular or linear distance between two adjacent elevation points.

Prohibited area. An airspace of defined dimensions, above the land areas or territorial waters of a State, within which the flight of aircraft is prohibited.

Requirement. Need or expectation that is stated, generally implied or obligatory (ISO 9000*).

Validation. Confirmation, through the provision of objective evidence, that the requirements for a specific intended use or application have been fulfilled (ISO 9000*).

Verification. Confirmation, through the provision of objective evidence, that specified requirements have been fulfilled (ISO 9000*).

ABBREVIATIONS

AIP: Aeronautical Information Publication

ANSP: Air Navigation Service Provider

AISP: Aeronautical Information Service Provider

AIXM: Aeronautical Information Exchange Model

ARP: Aerodrome Reference Point

ATS: Air traffic services

CAA: Civil Aviation Authority

DPS: Data product specification

EGM: Earth Gravitational Model

ICAO: International Civil Aviation Organisation

ISO: International Organisation for Standardisation

MSL: Mean sea level

NOTAM: Notice to Airmen

OLS: Obstacle Limitation Surface(s)

PANS-AIM: Procedures for Air Navigation Services — Aeronautical Information Management

PATC: Precision Approach Terrain Chart

SARP: Standards and Recommended Practices

SLA: Service Level Agreement

SVS: SYNTHETIC VISION SYSTEM

SWIM: System-Wide Information Management

TIN: Triangulated Irregular Network

TMA: Terminal Area

TOD: Terrain and obstacle data

UTC: Co-ordinated Universal Time

WGS-84: World Geodetic System-1984

0.6. CONTENTS

07. INTRODUCTION

Knowledge of terrain and obstacles is a requirement to ensure safety when evaluating structures to be built or altered in a State's airspace. Increased economic development and prosperity often include infrastructure (buildings, towers etc.) which may encroach upon airspace.

Due to the implications for air traffic and safety operations, it is essential that the impact of these obstacles is continuously assessed, reviewed, and updated. ICAO requires States to make terrain and obstacle data available to airspace users in electronic format.

0.8. PURPOSE OF THE DOCUMENT

This document provides assistance to those tasked with implementing electronic terrain and obstacle data. It seeks to provide the necessary guidance for operators.

The objective of this document is:

- For the data originators and data providers:
  - To support data originators and data providers to consider which terrain and obstacle should be collected and provided to the AIS.
  - To promote the harmonisation of the exchange of TOD.
- For the AIS:
  - To support the harmonised handling of the TOD received from the data originators and data providers.

0.9. SCOPE

This guidance is intended to be used by those bodies involved in the origination, processing and provision of electronic terrain and obstacle data, from the point at which the need for origination is identified, through to the point when the State makes it available in accordance with the requirements of TOD regulatory and PANS-AIM.

010. TARGET AUDIENCE

The target audience for this document includes, but is not limited to:

- data originators (airport operator, ANSP, etc.) sending data to the AIS;
- AIS personnel responsible for the collection and publication of data from the data originators or data providers;

CHAPTER 01. TOD REQUIREMENTS

1.1. INTRODUCTION

This section presents the text of TOD Regulatory. To provide coherent guidance, this chapter is structured by subject rather than by the order of the provisions. Guidance on each of the provisions can be found in one of the following four main sections:

- TOD relevant Areas and Surfaces,
- Provisions for Terrain Data Sets,
- Provisions for Obstacle Data Sets.

A user who seeks information on a particular provision may refer directly to the relevant sub-section without reading the entire chapter. As a result, some information is repeated where the provisions contain similar text.

1.2. TOD-RELEVANT AREAS AND SURFACES

Different geographic areas and 3D-surfaces constitute the spatial scope of the ICAO TOD provisions.

The majority of these areas and surfaces are related to airport geometry. They are defined in the following ICAO Annexes and PANS and are presented in this section:

- Annex 15 and PANS-AIM (coverage areas),
- Annex 14 (obstacle limitation surfaces),
- Annex 04 (take-off flight path area).

1.2.1. COVERAGE AREAS DEFINED TOD

1.2.1.1 OVERVIEW OF FOUR AREAS

ICAO has defined four coverage areas where different numerical requirements apply for terrain and obstacle data. The coverage areas for sets of electronic terrain and obstacle data shall be specified as:

- Area 1: The entire territory of a State
- Area 2: The vicinity of an aerodrome which was broken down into four sub-areas
  - Area 2a: A rectangular area around a runway that comprises the runway strip plus any clearway that exists;

    Note.— See ICAO Annex 14, Volume I, Chapter 3 for dimensions for runway strip.

  - 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;

- Area 3: An area bordering the movement area on an aerodrome
- Area 4: The radio altimeter area operating in front of a precision approach runway, Category II or III.

Where the terrain at a distance greater than 900 m (3 000 ft) from the runway threshold is mountainous or otherwise significant, the length of Area 4 should be extended to a distance not exceeding 2 000 m (6 500 ft) from the runway threshold.

1.2.1.1.1. AREA 1

Area 1 encompasses the entire territory of the State, including terminal control area and aerodromes/heliports and those areas over the high seas for which the State is responsible for the provision of air traffic services (ATS).

1.2.1.1.2. AREA 2

Area 2 is the terminal control area as defined in the Aeronautical Information Publication (AIP) of the State, limited to a maximum of 45 km from the ARP. For airfields which do not have a legally defined Terminal Area (TMA), Area 2 is the area covered by a radius of 45 km from the ARP excluding sub areas where flight operations are restricted due to high terrain or “no fly” conditions.

- Area 2a

Area 2a is a rectangular area which encompasses the runway strip and any clearways that exist. To elaborate, the rectangular area will comprise the area between the runway thresholds (or runway end(s) where displaced threshold(s) exist) and beyond this to the end of any defined clearway(s). Area 2a is intended to reduce the risk of damage to aircraft running off a runway and to protect aircraft flying over the strip and clearway during take-off or landing.

- Area 2b

Area 2b covers an area for take-off and landing and, as described, extends from the outer ends of Area 2a, with a 15% splay to either side and a length of 10 km.

- Area 2c

Area 2c is described as the area within 10km of the edges of Area 2a, excluding those parts identified as being Area 2b.

- Area 2d

Area 2d is identified as the area extending from the outer edges of Area 2a, Area 2b and Area 2c, out to a distance of 45 km from the aerodrome reference point or the TMA boundary, whichever is the closest. Given that the TMA boundary is only mentioned with respect to Area 2d, it is assumed that should the TMA end closer to Area 2a than 10 km, Area 2b and 2c would still extend to 10 km, despite extending further than the TMA boundary.

1.2.1.1.3. AREA 3

It is 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.

It should be noted that the movement area is defined as that part of an aerodrome to be used for the take-off, landing and taxiing of aircraft, consisting of the manoeuvring area and the apron(s). The taxiway shoulders are therefore not part of the movement area but part of Area 3, i.e. the 50 m bordering area starting at the edge of the taxiway and not at the edge of the taxiway shoulder.

1.2.1.1.4. AREA 4

It is 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. This area corresponds to the area of the Precision Approach Terrain Chart (PATC) as defined in ICAO Annex 4.

1.2.1.2. OBSTACLE LIMITATION SURFACES DEFINED IN ICAO ANNEX 14

ICAO Annex 14, Chapter 4 defines a series of obstacle limitation surfaces whose are to define the airspace around aerodromes to be maintained free from obstacles so as to permit the intended aeroplane operations at the aerodromes to be conducted safely and to prevent the aerodromes from becoming unusable by the growth of obstacles around the aerodromes.

ICAO Annex 14 section 4.1 defines the components which make up the obstacle limitation surfaces and it is the objects which penetrate these surfaces which must be included within the obstacle data set.

The obstacle limitation surfaces comprise of:

- Outer horizontal surface;
- Conical surface;
- Inner horizontal surface;
- Approach surface;
- Inner approach surface;
- Transitional surface;
- Inner transitional surface;
- Balked landing surface; and
- Take-off climb surface.

The precise dimensions of each of these surfaces varies depending upon the classification of the runway in question, with the dimensions being provided by ICAO Annex 14 in Table 4-1 for approach runways and Table 4-2 for runways meant for take-off.

Figure 1 provides a graphical representation of the listed obstacle limitation surfaces.

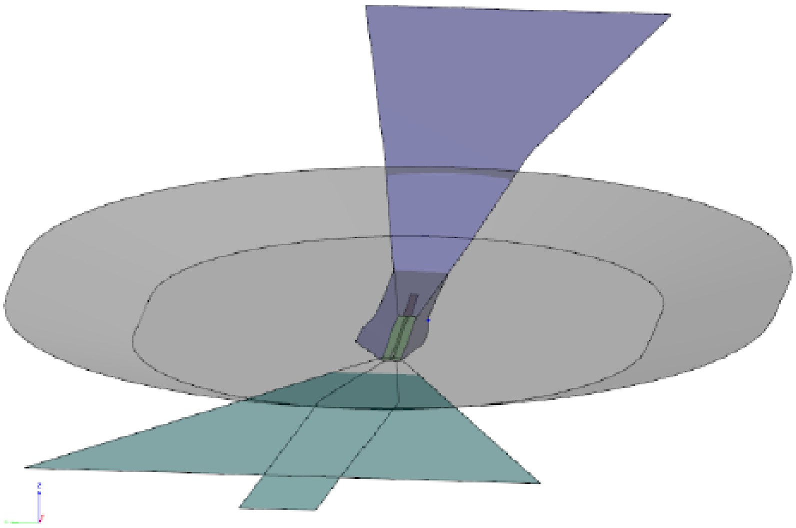

Figure 1: Graphical representation of the listed obstacle limitation surfaces

It should be noted that the obstacle limitation surfaces extend up to 15 km, which is different to Area 2b, whose extension is only 10 km.

1.2.1.3. TAKE-OFF FLIGHT PATH AREA DEFINED IN ICAO ANNEX 4

The take-off flight path area is defined in ICAO Annex 4 Paragraph 3.8.2.1:

The take-off flight path area consists of a quadrilateral area on the surface of the earth lying directly below, and symmetrically disposed about, the take-off flight path. This area has the following characteristics:

a) it commences at the end of the area declared suitable for take-off (i.e. at the end of the runway or clearway as appropriate);

b) its width at the point of origin is 180 m (600 ft) and this width increases at the rate of 0.25D to a maximum of 1 800 m (6 000 ft), where D is the distance from the point of origin;

c) it extends to the point beyond which no obstacles exist or to a distance of 10.0 km (5.4 NM), whichever is the lesser.

Figure 2 provides a graphical representation of take-off flight path area as defined in ICAO Annex 4.

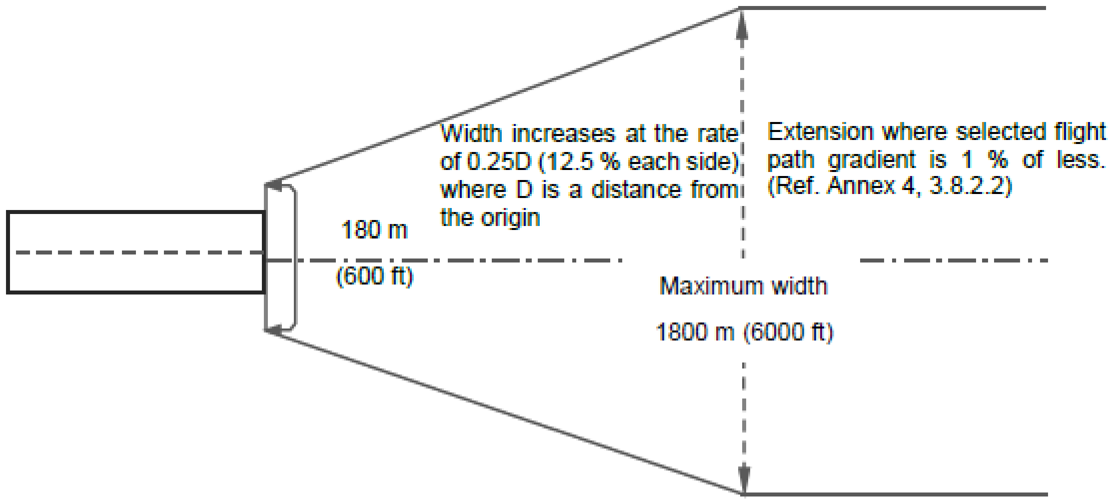

Figure 2: Graphical representation of take-off flight path area as defined in ICAO Annex 4

1.2.2. GENERAL REQUIREMENTS

1.2.2.1. HORIZONTAL REFERENCE SYSTEM

REQUIREMENT 1: World Geodetic System-1984 (WGS-84) shall be used as horizontal reference system for Terrain and Obstacle Data

REQUIREMENT 2: If TOD have been surveyed in other reference, frame the appropriate transformation should be applied to the data to produce coordinates in a world-wide, consistent reference frame (WGS-84)

REQUIREMENT 3: If data that has been transformed from one reference frame to another is stored, the original data item should also be stored with it as metadata, along with details of the reference frame used for origination

REQUIREMENT 4: The version of the horizontal reference frame used shall be recorded as metadata at the level of the data item.

REQUIREMENT 5: The horizontal reference frame used in TOD origination shall be recorded, together with the coordinates, as (lineage) metadata.

1.2.2.2. VERTICAL REFERENCE SYSTEM

REQUIREMENT 6: Mean sea level (MSL) datum shall be use as the vertical reference system for Terrain and Obstacle Data.

REQUIREMENT 7: A geoid model sufficient to meet the ICAO requirements shall be used to determine the MSL reference surface.

REQUIREMENT 8: Earth Gravitational Model (EGM) 1996 (EGM-96) must be used as the global gravity model for the publication of vertical information of TOD.

REQUIREMENT 9: Where a geoid model other than the Earth Gravitational Model (EGM) 1996 (EGM-96) is used, the geoid model should be made available in compliance with the International Organisation for Standardisation's (ISO) 19111:2007 "Geographic information - Spatial referencing by coordinates.

REQUIREMENT 10: The information about the geoid model used for the expression of elevations shall be recorded, together with the elevation value, as (lineage) metadata at the level of the data item.

1.2.2.3. TEMPORAL REFERENCE SYSTEM

REQUIREMENT 11: The temporal reference system used for TOD shall be the Gregorian calendar and Co-ordinated Universal Time (UTC).

1.2.2.4. UNITS OF MEASUREMENT

REQUIREMENT 12: The units of measurement in which data is provided must be in accordance with ICAO Annex 5.

REQUIREMENT 13: For TOD, the unit of measurement shall be recorded as metadata.

REQUIREMENT 14: Positions should be recorded in a way that they meet the defined data quality requirements for the data item.

1.2.2.5. METADATA

REQUIREMENT 15: Each data set shall be provided to the next intended user together with at least the minimum set of metadata that ensures traceability. The metadata shall include as a minimum:

a) the names of the organizations or entities performing any action of originating, transmitting or manipulating the data;

b) the action performed or amendments made to the data;

c) details of any validation and verification of the data that has been performed

d) the date and time the action was performed and when the data set was provided;

e) period of validity of the data set;

f) for geospatial data:
   - the earth reference model used,
   - the coordinate system used;

g) for numerical data:
   - the statistical accuracy of the measurement or calculation technique used
   - the resolution,
   - the confidence level as required by the ICAO standards

h) details of any functions applied if data has been subject to conversion/transformation

i) details of any limitations with regard to the use of the data set.

1.3. SPECIFIC REQUIREMENTS PROVISIONS FOR TERRAIN DATA SETS

1.3.1. DEFINITION OF TERRAIN

Terrain is 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, as shown in the following figure:

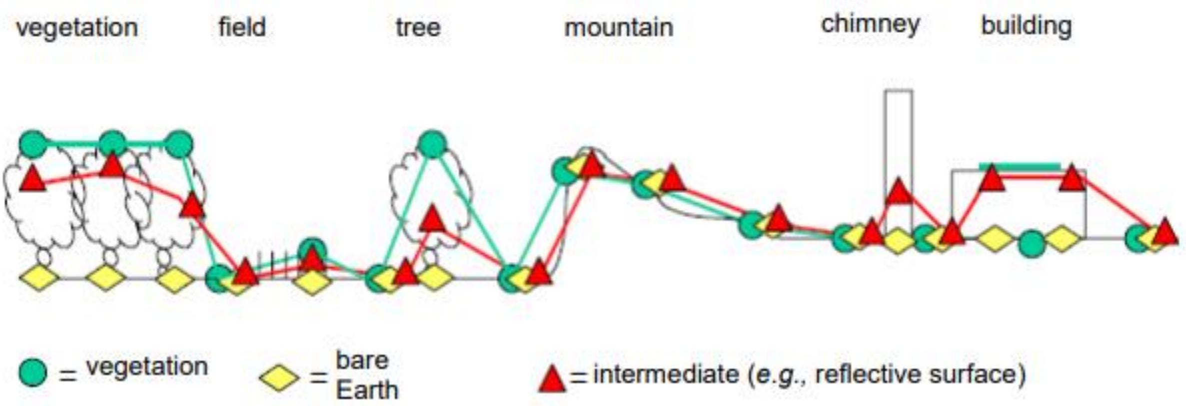

Figure 3: Terrain definition

The terrain must be represented by elevation at regular intervals. The result is a digital elevation model.

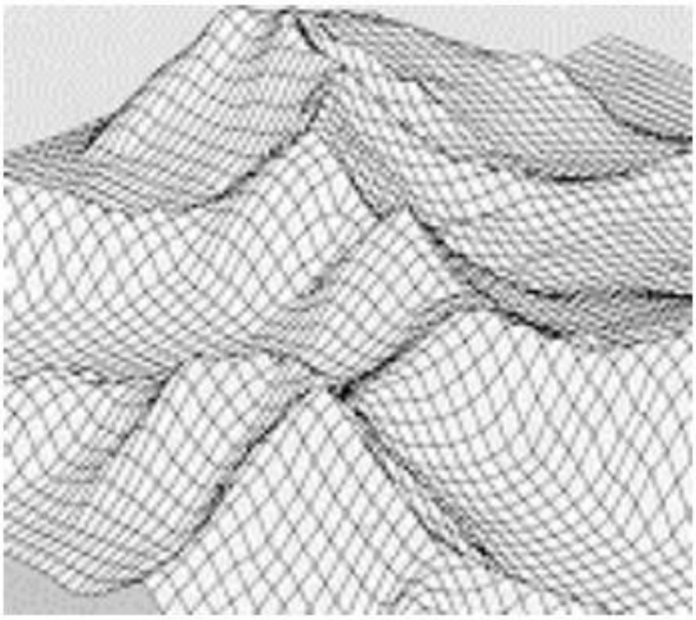

Figure 4: Elevation grid

Therefore, digital elevation models (DEM) are defined as the 3-D representation of terrain surface by continuous elevation values at all intersections of a defined grid, referenced to a common datum.

1.3.2. TERRAIN DATA QUALITY REQUIREMENTS

REQUIREMENT 16: Terrain data sets shall contain digital representation of the 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.

This text provides the following requirements:

a) The terrain data must be based upon a defined grid. “Defined” is understood to indicate that the spatial representation of the grid should be documented (coordinate reference system used, elevation reference, etc.);

b) The elevation of the terrain must be provided for each cell of the grid;

c) The elevations provided in the data set are all to be based upon a single vertical reference.

d) Although not explicitly stated, it is assumed that a single horizontal reference will also be used to define the grid. This is of particular relevance when terrain data is provided in multiple grids within a data set;

e) The terrain grid may be angular (meaning that it is based upon a grid which is formed by lines of latitude and longitude) or linear (meaning that the distance between the posts is fixed);

f) A regular-shaped terrain data set is typically understood as a raster built by cells. Irregular terrain data sets are based on an irregular set of points (i.e. they are unevenly distributed) which are used to create a TIN.

REQUIREMENT 17: Sets of electronic terrain data shall include spatial (position and elevation), thematic and temporal aspects for the surface of the Earth containing naturally occurring features such as mountains, hills, ridges, valleys, and bodies of water and exclude obstacles. Depending on the acquisition method used, this shall represent the continuous surface that exists at the bare Earth, the top of the canopy or something in-between, also known as “first reflective surface.

This standard provides clarification of what should be considered as terrain and, hence, captured for inclusion within the terrain data set.

Firstly, the requirement is for the data set to include:

- Positional information – the horizontal and vertical location for the terrain elevation value provided ;
- Thematic aspects of the terrain: this means that the surface type of the terrain may be gathered because it is considered to be beneficial for the selection of en-route emergency landing locations;
- Temporal aspects indicate that information related to the date and time at which the data was captured must be gathered and recorded. It should be noted that a single data set may include terrain which has been captured at many different points in time.

The standard goes on to state that the terrain modelled should reflect the surface of the earth and that, in particular, this includes areas of water. This indicates that the terrain model is not intended to provide information relating to the sea bed or the bottom of lakes/rivers etc.

REQUIREMENT 18: Terrain data sets shall be provided for Area 1.

This standard requires an electronic terrain data set to be provided for the entire territory of the State.

Table 1 presents the quality requirements for terrain data in Area 1.

REQUIREMENT 19: For aerodromes regularly used by international civil aviation, terrain data shall be provided for:

a) Area 2a;

b) the take-off flight path area; and

c) an area bounded by the lateral extent of the aerodrome obstacle limitation surfaces.

This standard defines the minimal required set of electronic terrain data for Area 2 to be provided for all aerodromes designated as international in the National AIP section AD 1.3 – 'Index to aerodromes and heliports'.

It should be noted that the requirement defines only the lateral extent of the area where terrain data must be provided, independent of terrain height. Even though Figure 5 mentions that Area 1 numerical requirements are sufficient for terrain beyond 10 km of the ARP lower than 120 m above the lowest runway, all terrain data must be provided with Area 2 numerical requirements within the bounds defined in points a), b) and c).

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.

Table 1 presents the quality requirements for terrain data in Area 2.

REQUIREMENT 20: For aerodromes regularly used by international civil aviation, additional terrain data should be provided within Area 2 as follows:

a) In the area extending to a 10-km radius from the ARP; and

b) Within the area between 10 km and the TMA boundary or a 45-km radius (whichever is smaller), where terrain penetrates a horizontal terrain data collection surface specified as 120 m above the lowest runway elevation.

ICAO recommends that, in addition to the minimal set of electronic terrain specified, terrain data should be provided for all of Area 2 for all aerodromes designated as international in the National AIP section AD 1.3 – 'Index to aerodromes and heliports'.

It will be provided all terrain data within a 10 km radius from the ARP, and beyond the 10 km radius only data for terrain that is above 120 m of the lowest runway elevation.

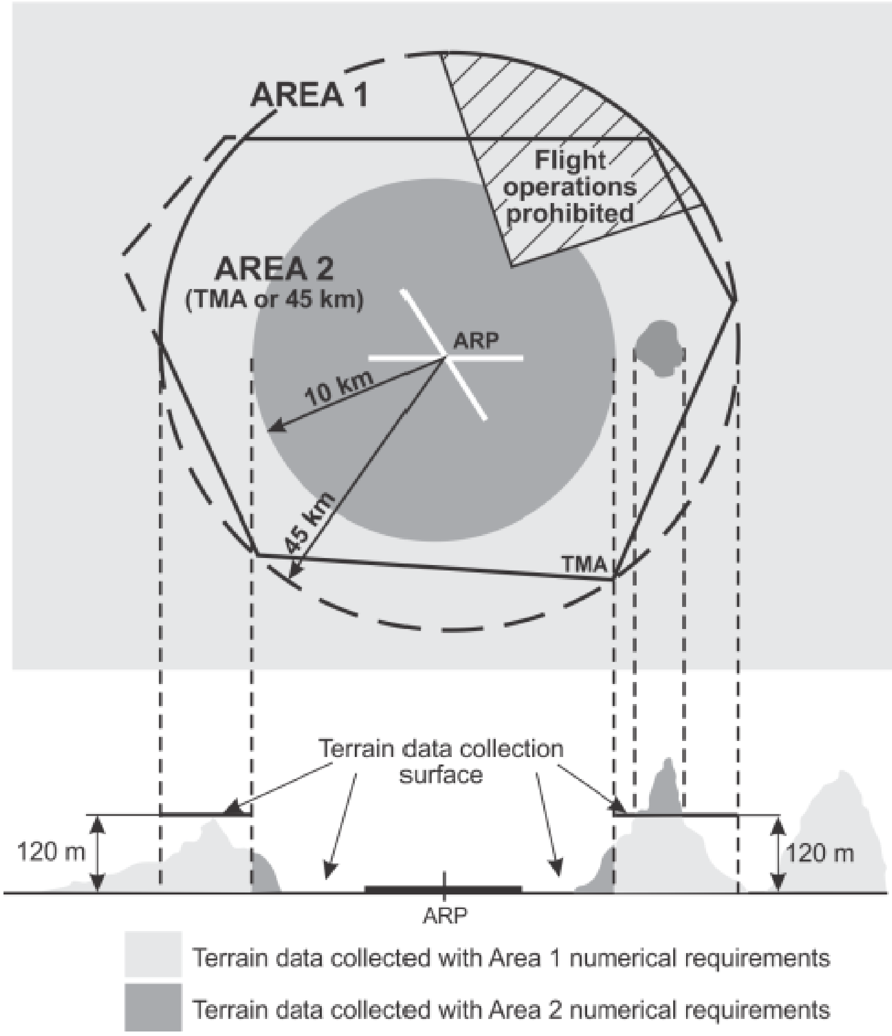

Figure 5: Terrain data collection surfaces — Area 1 and Area 2

REQUIREMENT 21: For aerodromes regularly used by international civil aviation, terrain data should be provided for Area 3.

When surveying terrain, the horizontal spatial extent to be surveyed must include the aerodrome surface movement area plus a buffer of 50 meters or the minimum separation distances specified in Doc 9157, whichever is greater.

When surveying terrain from a runway, the horizontal spatial extent to be surveyed must cover the area that extends from the edge(s) of the runway(s) to 90m from the runway centreline(s) (see Figure 6).

All terrain in the horizontal spatial extent region that extend more than 0.5 meters above the horizontal plane passing through the nearest point on the aerodrome surface movement area may be hazardous for surface movement and must, therefore, be surveyed.

Table 1 presents the quality requirements for terrain data in Area 3.

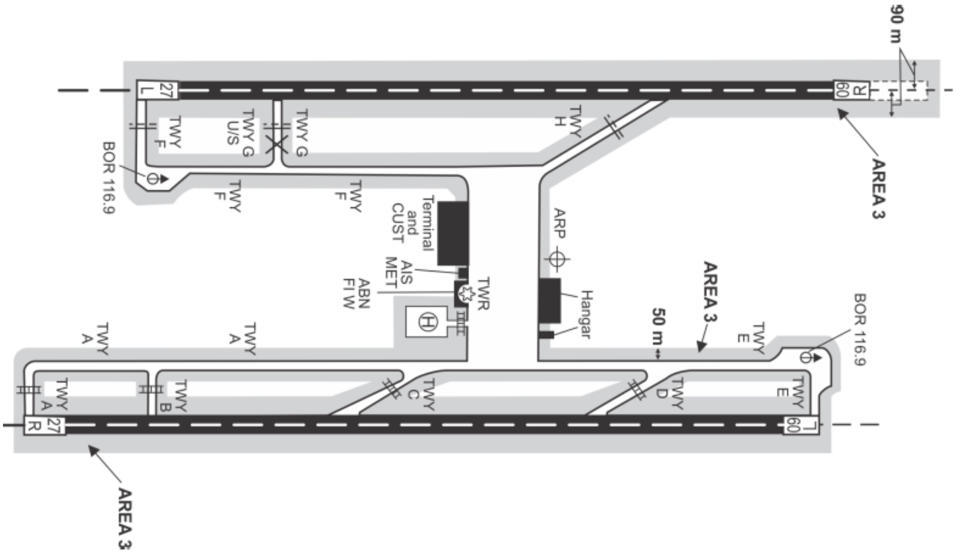

Figure 6: Terrain data collection surface — Area 3

REQUIREMENT 22: For aerodromes regularly used by international civil aviation, terrain data shall be provided for Area 4 for all runways where precision approach Category II or III operations have been established and where detailed terrain information is required by operators to enable them to assess the effect of terrain on decision height determination by use of radio altimeters.

This standard requires that terrain data for Area 4 is made available for Cat II/III runways of all aerodromes designated as international in the National AIP section AD 1.3 – 'Index to aerodromes and heliports'. Table 1 presents the quality requirements for terrain data in Area 4.

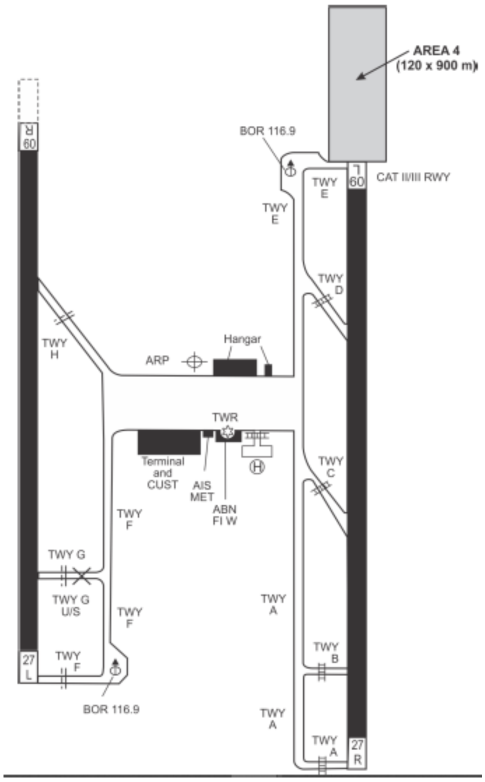

Figure 7: Terrain data collection surface — Area 4

REQUIREMENT 23: Where the terrain at a distance greater than 900 m (3 000 ft) from the runway threshold is mountainous or otherwise significant, the length of Area 4 should be extended to a distance not exceeding 2 000 m (6 500 ft) from the runway threshold.

Area 4 data is intended to provide a digital representation of the information typically provided by way of the PATC, which is required to be provided as part of the AIP and is detailed in ICAO Annex 4.

REQUIREMENT 24: Where additional terrain data is collected to meet other aeronautical requirements, the terrain data sets should be expanded to include this additional data.

In order to meet other needs, ANSP or aerodrome operator may capture other electronic terrain data which is not strictly required by the TOD regulatory. For example, a non-standard departure/arrival procedure could require additional terrain data outside the lateral limits of OLS.

Table 1. Terrain Data Numerical Requirements

	Area 1	**Area 2**	**Area 3**	**Area 4**
Post spacing	3 arc seconds (approx. 90 m)	1 arc second (approx. 30 m)	0.6 arc seconds (approx. 20 m)	0.3 arc seconds (approx. 9 m)
Vertical accuracy	30 m	3 m	0.5 m	1 m
Vertical resolution	1 m	0.1 m	0.01 m	0.1 m
Horizontal accuracy	50 m	5 m	0.5 m	2.5 m
Confidence level	90%	90%	90%	90%
Integrity classification	routine	essential	essential	essential
Maintenance period	as required	as required	as required	as required

REQUIREMENT 25: Arrangements shall be made for coordinating the provision of terrain data for adjacent aerodromes where their respective coverage areas overlap to assure that the data for the same terrain is correct.

When aerodromes are located relatively close to each other the Area 2 for the aerodromes overlaps. This is especially true when the full 45km is considered or a shared Terminal Area (TMA) exists for the aerodromes.

In this case, the requirement demand that arrangements need to be established between these aerodromes to ensure that the terrain data for these overlapping areas is "correct". It is considered important to define what is meant by "correct".

Two aerodromes could independently collect terrain and obstacle data and, in one case, the data is in fact higher than reality but within the accuracy requirements, and in the other, lower but, again, within the accuracy requirements. Similarly, the horizontal accuracies may be met in both cases but the two sets of data itself may be horizontally offset.

Such a situation is to be avoided wherever possible and this is the purpose of this Recommended Practice. The ideal situation would be for the aerodromes to work together to jointly procure a single survey as this would lead to a single, consistent data set. Where a single survey is not possible, the relevant aerodrome authorities should take steps to agree a single, harmonised representation of the terrain and obstacles in the overlapping area, whilst ensuring that the join between the overlapping and non-overlapping areas remains consistent

REQUIREMENT 26: For those aerodromes located near territorial boundaries, arrangements shall be made among States concerned to share terrain data.

When aerodromes are located very close to State boundaries and, in some cases, the TMA extends into the neighbouring State's territory. In these circumstances, there may be a need to collect data for those portions of Area 2 which are located in the neighbouring State.

Where there is a need for the collection of data for territory not under the direct responsibility of the State in which the aerodrome is located, agreements need to be reached for the collection of this data.

REQUIREMENT 27: In terrain data sets, only one feature type, i.e. terrain, shall be provided. Feature attributes describing terrain shall be those listed TOD Regulatory framework, Appendix 2, Table 1. The terrain feature attributes listed in Table 1 represent the minimum set of terrain attributes, and those annotated as mandatory shall be recorded in the terrain data set.

This standard further elaborates the content of the terrain data set, once again stating that only terrain shall be included. In specifying the attributes that should be provided in the data set, it references TOD regulatory as providing the minimum set of attributes that must be provided. As indicated, some of these attributes are mandatory and have to be provided, whereas others are optional. As this attribute list is described as the minimum set that must be provided, it is considered that additional attributes may be provided, where appropriate. The attributes can be provided either as metadata (e.g. horizontal and vertical reference system) or as data (e.g. elevation, surface type).

1.4. SPECIFIC REQUIREMENTS FOR OBSTACLE DATA SETS

1.4.1. DEFINITION OBSTACLES

Obstacle: All fixed (whether temporary or permanent) or mobile objects, or parts thereof, that:

a) are 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 that have been assessed as being a hazard to air navigation.

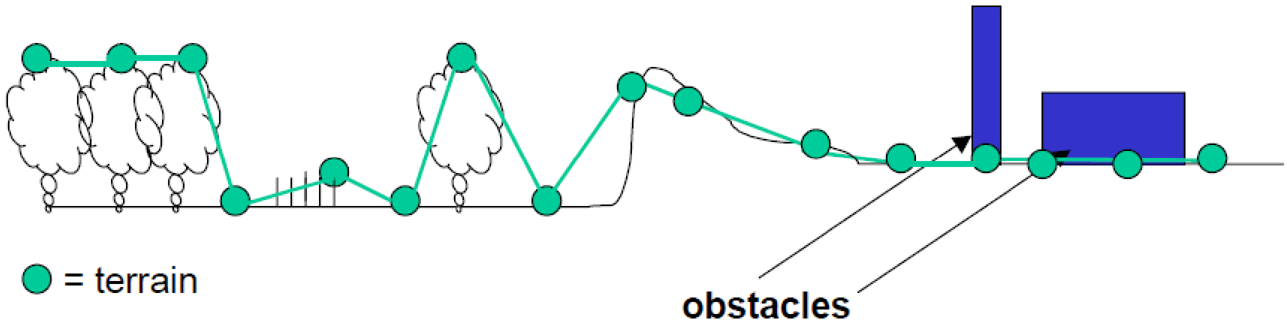

Figure 8: Obstacle definition

1.4.2. OBSTACLE DATA QUALITY REQUIREMENTS

REQUIREMENT 28: Obstacle data sets shall contain the digital representation of the vertical and horizontal extent of the obstacles. Obstacle data shall not be included in terrain data sets.

REQUIREMENT 29: Obstacle data elements are features that shall be represented in the data sets by points, lines or polygons.

These provisions define what is meant by obstacle data, reiterating that obstacles must not be included in the terrain data set. They indicate that obstacle data should provide a representation of the horizontal and vertical extent of the obstacles, in a digital form and outline that these extents may be defined as a:

- Point: A single geographical location;
- Line: A series of geographical locations, comprising a minimum of two points;
- Polygon: A series of geographical locations that must be closed to form a complete bounding box.

Guidance on feature capture rules is provide in Annex 1

REQUIREMENT 30: Obstacle data shall be provided for obstacles in Area 1 whose height is 100 m or higher above ground.

Every obstacle within Area 1 whose height above the ground is equal to or greater than 100 m must be collected and recorded in the obstacle database in accordance with the Area 1 obstacle data quality requirements specified on Figure 15.

REQUIREMENT 31: For aerodromes regularly used by international civil aviation, obstacle data shall be provided for all obstacles within Area 2 that are assessed as being a hazard to air navigation.

The text "aerodromes regularly used by international civil aviation" means all aerodromes designated as international in the National AIP section AD 1.3 - Index to aerodromes and heliports.

REQUIREMENT 32: All obstacles which exist within the region defined as Area 2a and that intersect a horizontal plane 3m above the nearest runway elevation measured along the runway centre line, and for those portions related to a clearway, if one exists are to be provided in the digital data set with the Area 2 numerical requirements defined on Figure 15.

It should be noted that the obstacle collection surface can have a different elevation at each point along the runway according to the longitudinal profile of the runway centre line (see Figure 9). Therefore, the minimum height of an obstacle in Area 2a depends on the elevation of the nearest point on the centreline and the terrain elevation.

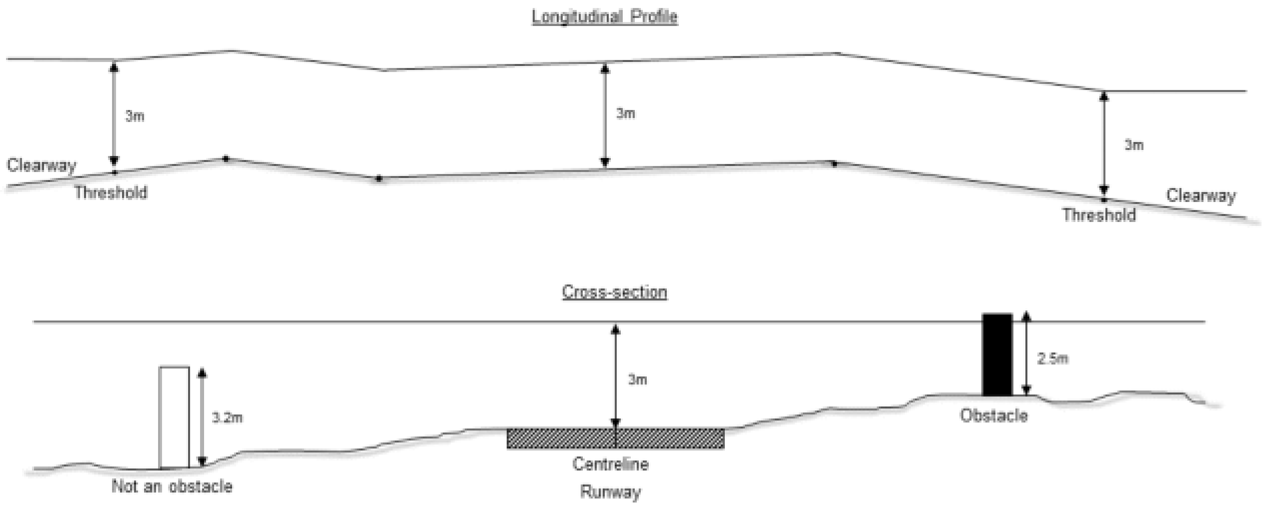

Figure 9: Obstacles in Area 2a

Objects in the take-off flight path area

Objects in the take-off flight path area which project above a plane surface having a 1.2 per cent slope and having a common origin with the take-off flight path area (i.e. at the end of the runway or clearway as appropriate) must be made available with the Area 2 numerical requirements defined on Figure 15.

It is, therefore, necessary to include those obstacles which must be included on the Aerodrome Obstacle Chart — ICAO Type A (Operating Limitations) in order to meet this clause.

It should be noted that according to the requirements in ICAO Annex 4 not all obstacles penetrating the 1.2% surface are shown on the Aerodrome Obstacle Chart — ICAO Type A: obstacles lying wholly below the shadow of other obstacles need not to be shown. This is not the case for the Area 2 obstacle data set. All obstacles penetrating the 1.2% surface in the take-off flight path area have to be included in the data set.

Penetrations of the aerodrome obstacle limitation surfaces:

Objects penetrating the aerodrome obstacle limitation surfaces must be provided with the Area 2 numerical requirements defined on Figure 15.

REQUIREMENT 33:

Obstacles in Area 2b

Area 2b is 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 per cent to each side. The Area 2b obstacle collection surface has a 1.2 per cent 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 per cent to each side.

This surface commences at the elevation of the nearest runway threshold or runway end, in case of a displaced threshold.

As indicated by the figure 11, all obstacles which penetrate this surface and whose height above ground level is 3m or greater must be collected.

Obstacles in Area 2c

Area 2c is 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 obstacle collection surface has a 1.2 per cent 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 has the elevation of the point of Area 2a at which it commences.

As indicated by the figure 11, all obstacles which penetrate this surface and whose height above ground level is 15m or greater must be collected.

Obstacles in Area 2d

Area 2d is an area outside 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.

It should be noted that there are certain areas (see Figure 10) where the Area 2 surfaces with the 1.2% slope are situated above the obstacle limitation surfaces and therefore less restrictive for obstacle data collection. Nevertheless, all obstacles penetrating an OLS must be included in the Area 2 obstacle data set.

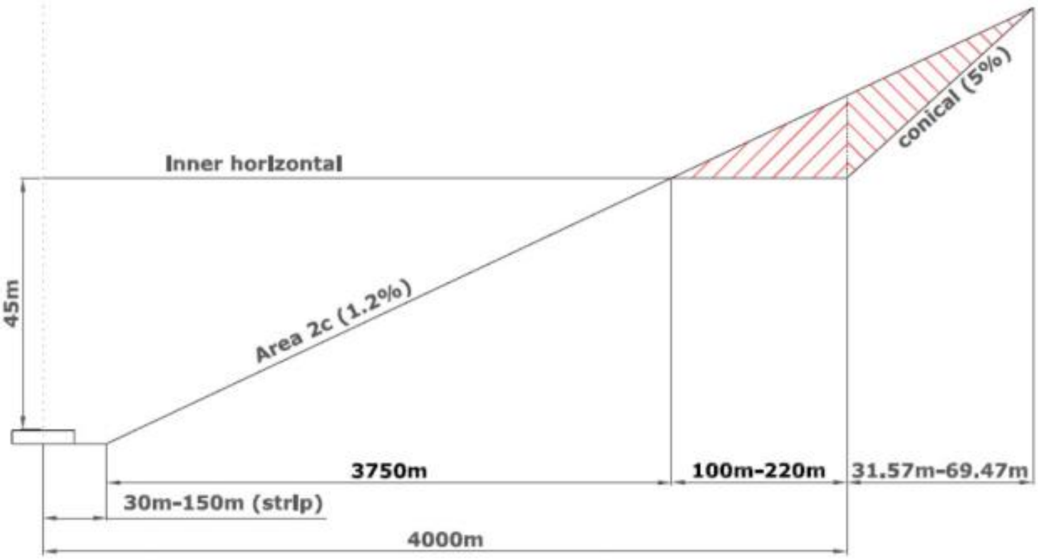

Figure 10: Gaps between Area2c 1.2% Surface and Obstacle Limitation Surfaces

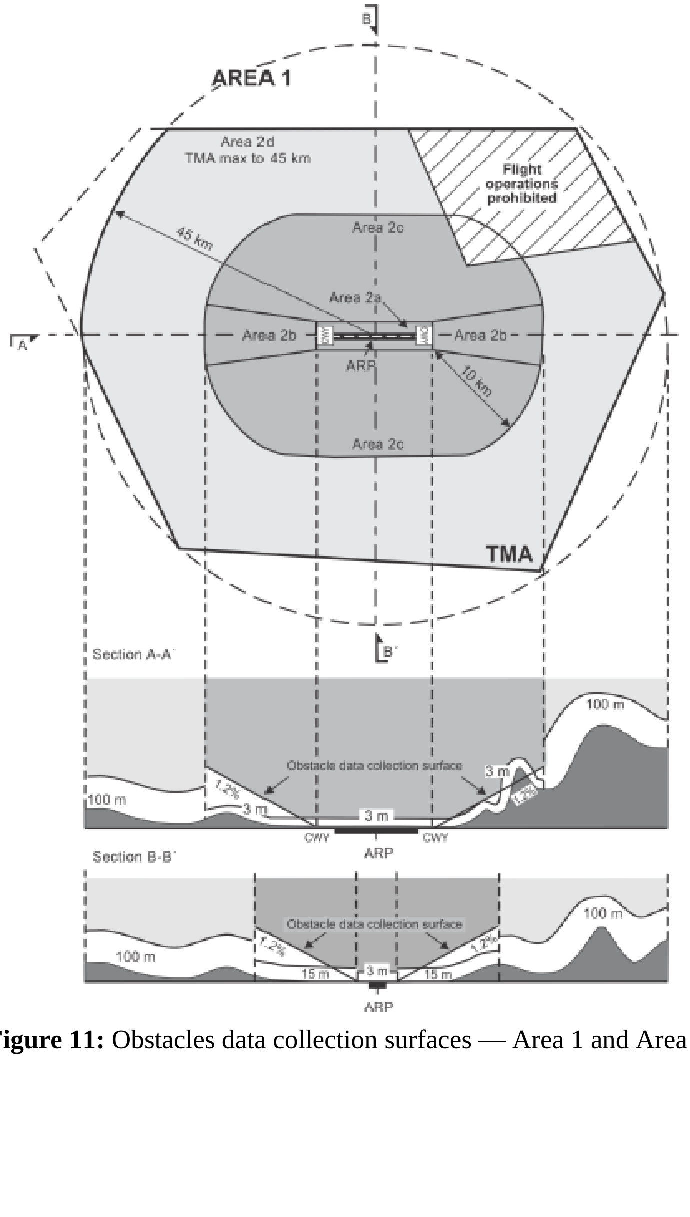

Figure 11: Obstacles data collection surfaces — Area 1 and Area 2

1 Obstacle data shall be collected and recorded in accordance with the Area 2 numerical requirements specified on figure 15.

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.

3 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 specified on figure 15.

REQUIREMENT 34: The obstacle data product specification, supported by geographical coordinates for each aerodrome included within the data set, shall describe the following areas:

a) Areas 2a, 2b, 2c, 2d;

b) the take-off flight path area; and

c) the obstacle limitation surfaces.

The “specification scope” section of the DPS allows to differentiate the specification of obstacle data based on spatial or temporal extents (areas) or feature types (terrain vs. obstacle). This requirement states that such differentiation shall be made in the DPS. Although not explicitly stated, it is recommended that the “specification scope” section is used for the definition of the different areas (1, 2a, 2b, 2c, 2d, 3 and 4).

The take-off flight path area and the obstacle limitation surfaces have an impact on data capture and so it is important that these, and their impacts, are specified in the DPS. The requirement specifies that geographical coordinates shall be used to describe the geographical extents of these areas.

REQUIREMENT 35: obstacle data for Area 3 for obstacles that penetrate the relevant obstacle data collection surface extending a half-metre (0.5 m) above the horizontal plane passing through the nearest point on the aerodrome movement area in aerodromes regularly used by international civil aviation shall be provided.

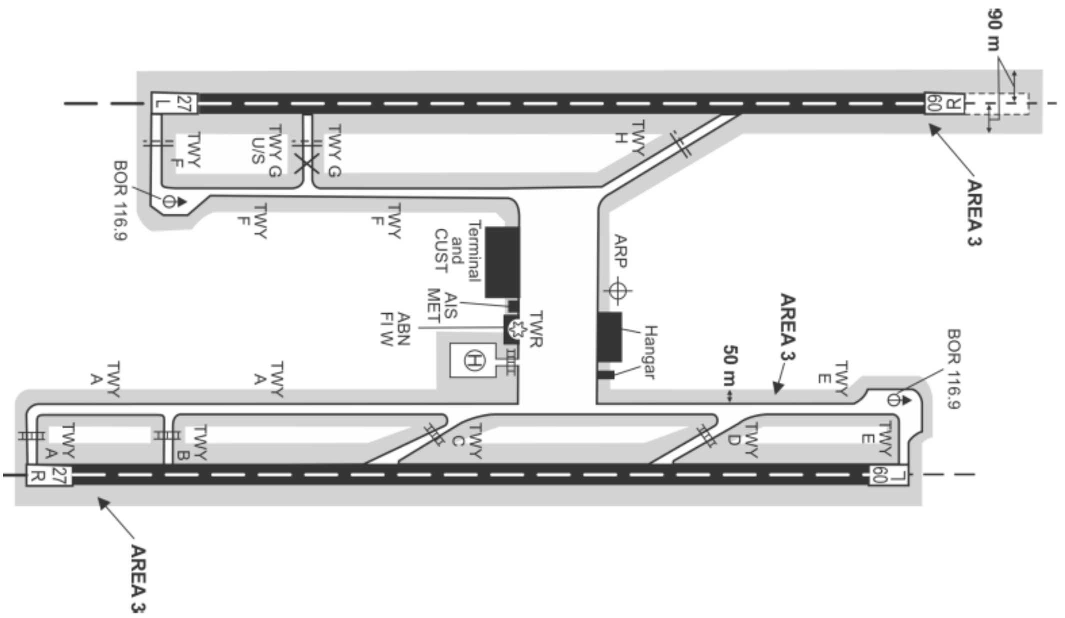

Figure 12: Obstacle data collection surface — Area 3

Data collection for obstacles in Area 3 extends a half-metre (0.5 m) above the horizontal plane passing through the nearest point on the aerodrome movement area. It should be noted that this is not a requirement for the minimal height of obstacles. As illustrated in Figure 13, depending on the terrain, obstacles with a height of less than 0.5 m can penetrate this surface and objects higher than 0.5 m can remain below the collection surface.

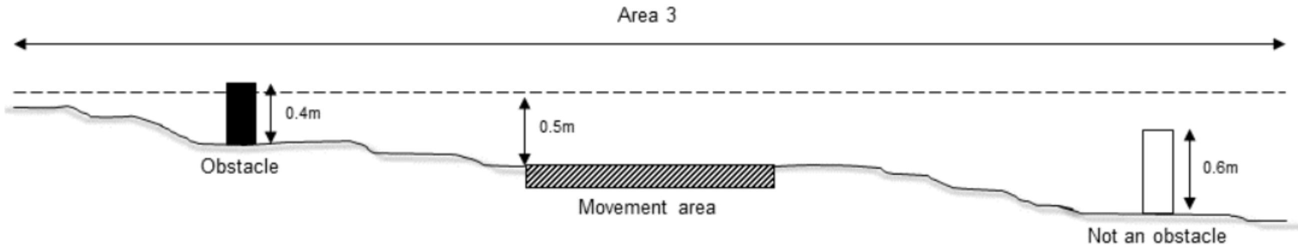

Figure 13: Obstacles in Area 3

REQUIREMENT 36: For aerodromes regularly used by international civil aviation, obstacle data shall be provided for Area 4 for all runways where precision approach Category II or III operations have been established.

When obstacle data is collected, it should be done so in accordance with the Area 4 numerical requirements specified on figure 15.

The ICAO requirement does not specify the minimum obstacle collection surface for Area 4. However, since the vertical accuracy for Area 4 is 1 m, it is recommended that obstacle data for all objects over one (01) meter in height (above ground level) be provided.

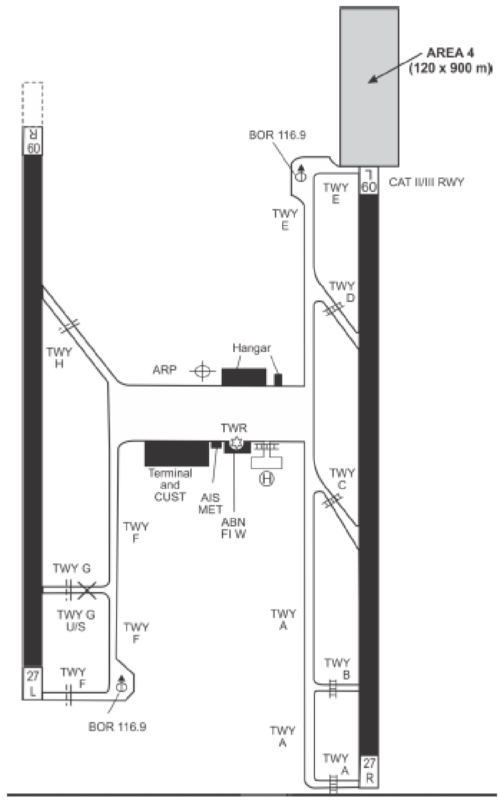

Figure 14: Obstacles in Area 4

Table A1-6 Obstacle data

Subject	Property	Sub-Property	Type	Description	Note	Accuracy	Integrity	Orig Type	Pub. Res.	Chart Res.
Obstacle				All fixed (whether temporary or permanent) and mobile						
	Obstacle identifier		Text	Unique identifier of obstacle						
	Operator / Owner		Text	Name and Contact information of obstacle operator or owner						
	Geometry type		Code list	An indication whether the obstacle is a point, line or polygon.						
	Horizontal position		Point Line Polygon	Horizontal position of obstacle		See Note 1)				
	Horizontal extent		Distance	Hoizontal extent of the obstacle						
	Elevation		Elevation	Elevation of the highest point of the obstacle.		See Note 2)				
	Height		Height	Height of the obstacle above ground						
	Type		Text	Type of obstacle						
	Date and time stamp		Date	Date and time the obstacle was created						
	Operations		Text	Feature operations of mobile obstacles						
	Effectivity		Text	Effectivity of temporary types of obstacles						
	Lighting									
		Type	Text	Type of lighting						
		Colour	Text	Colour of the obstacle lighting						
	Marking		Text	Type of marking of obstacle						
	Material		Text	Predominant surface material of the obstacle						
			Note 1)	Obstacles in Area 1		50 m	routine	surveyed	1 sec	as plotted
				Obstacles in Area 2 (including 2a, 2b, 2c, 2d, take-off flight path area and		5 m	essential	surveyed	1/10 sec	1/10 sec
				Obstacles in Area 3		0.5 m	essential	surveyed	1/10 sec	1/10 sec
				Obstacles in Area 4		2.5 m	essential	surveyed		
			Note 2)	Obstacles in Area 1		30 m	routine	surveyed	1 m or 1 ft	3 m (10 ft)
				Obstacles in Area 2 (including 2a, 2b, 2c, 2d, take-off flight path area and		3 m	essential	surveyed	1 m or 1 ft	1 m or 1 ft
				Obstacles in Area 3		0.5 m	essential	surveyed	0.1 m or 0.1	1m or 1 ft
				Obstacles in Area 4		1 m	essential	surveyed	0.1 m	

Figure 15: Obstacle numerical requirements

REQUIREMENT 37: Where additional obstacle data is collected to meet other aeronautical requirements, the obstacle data sets should be expanded to include this additional data.

In order to meet other needs, ANSP or aerodrome operator may capture other electronic obstacle data which is not strictly required by the TOD regulatory.

In such cases, ANSP or aerodrome operator may also wish to include these obstacles within their digital data sets, so as to provide a more complete data set. The objects which are not considered to be obstacles according to the definition given in the SARPs) should be declared as such in the metadata.

REQUIREMENT 38: Arrangements shall be made for coordinating the provision of obstacle data for adjacent aerodromes where their respective coverage areas overlap to assure that the data for the same obstacle is correct.

When aerodromes are located relatively close to each other the Area 2 for the aerodromes overlaps. This is especially true when the full 45km is considered or a shared Terminal Area (TMA) exists for the aerodromes

The Requirement demand that arrangements need to be established between these aerodromes to ensure that the obstacle data for these overlapping areas is “correct”. It is considered important to define what is meant by “correct”.

Two aerodromes could independently collect obstacle data and, in one case, the data is in fact higher than reality but within the accuracy requirements, and in the other, lower but, again, within the accuracy requirements. Similarly, the horizontal accuracies may be met in both cases but the two sets of data itself may be horizontally offset.

As the vertical accuracy for Area 2 is 3m and the horizontal accuracy is 5m, in the worst case, the two aerodromes could legitimately reflect the same obstacle with a 6m difference in height/elevation and a 10m difference in location. This is obviously not an ideal situation.

Such a situation is to be avoided wherever possible and this is the purpose of this requirement. The ideal situation would be for the aerodromes to work together to jointly procure a single survey as this would lead to a single, consistent data set. It is, however, apparent that such arrangements will not always be feasible. Where a single survey is not possible, the relevant aerodrome authorities should take steps to agree a single, harmonized representation of the obstacles in the overlapping area, whilst ensuring that the join between the overlapping and non-overlapping areas remains consistent.

REQUIREMENT 39: For those aerodromes located near territorial boundaries, arrangements should be made among States concerned to share obstacle data.

when aerodrome is located very close to State boundaries and, in some cases; the TMA extends into the neighboring State's territory. In these circumstances, there may be a need to collect data for those portions of Area 2 which are located in the neighboring State.

For the collection of the data for territory not under the direct responsibility of the State in which the aerodrome is located, there is the need for agreements to be reached for the collection of this data. In such cases, arrangements shall be made between the relevant States to ensure that this terrain and obstacle data is collected in a manner, which allows it to be shared, and, therefore provides a cost-effective solution.

REQUIREMENT 40: 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 TOD Regulatory framework, third schedule Table S8-2.

This provision defines the content of the obstacle data set by specifying the attributes that must be provided in the data set. These obstacle attributes can be provided either as metadata or as data (properties of the obstacle features).

CHAPTER 02. TOD IMPLEMENTATION PROCESS

This chapter provides guidelines that must be followed to plan and implement terrain and obstacle data on a national basis.

To allow better monitoring of the implementation of the defined steps, implementation TOD checklist is proposed for operators (see Annex B).

2.1. DATA ORIGINATION

2.1.1. IDENTIFICATION OF SOURCES OF DATA

ANSP and aerodrome operator must identify the sources of such data. In general, terrain data is available at State geographical institutes. There may also be other providers of such data.

As to obstacles, data may be available from:

- Mobile telephone companies (antennae, transmission frequencies),
- Aviation service provider (NAVAIDS / aerodrome data),
- Airports (aerodrome data),
- Public service authorities (electric lines, dams, cable railways, chimneys, wind mills, etc.),
- Military,
- Local authorities (buildings),
- Existing studies on obstacles.

It recommended to establish the points of contact for each party.

These sources will provide all the basic data for building an TOD database, which will be modified as new data emerges, or when the existing data is modified or deleted.

TOD stakeholders have to make an inventory of and evaluate the quality of existing terrain and obstacle data sources, and in the case of data collection, consider carefully the required level of details of collected.

It is recommended that meetings be held with these organisations. Discussions should take place on the feature capture rules to be applied (see Annex A), data liability for data originators and costs and licensing for data sources.

It is recommended that once appropriate data sources and/or originators have been identified and the provision of data agreed by the data source and/or originator, that formal arrangements be established between the data provider and the recipient. According to TOD regulatory, CAA must ensure that formal arrangements are established between originators of aeronautical data and aeronautical information and the aeronautical information service in relation to the timely and complete provision of aeronautical data and aeronautical information. If the provision of data is likely to take place regularly, over a period of time, a Service Level Agreement (SLA) may be an appropriate means of formalising the data provision.

The content or elements of formal agreement for TOD are precised in AFI AIM RBIS TOD SLA with data originators and AIS template.

2.1.2. DATA COLLECTION

Once originating data sources, both internal and external, have been identified, and taking into account that such sources are capable of sharing such data, the organization responsible for data collection may import the available electronic data. These organisation may be ANSP or Aerodrome operator.

Similarly, the imported data may be incomplete, given the fact that there are much more data still uncollected. In that case, and if no terrain and obstacle data were available, an analysis shall be made of how to obtain them.

The TOD stakeholders must create mechanisms for collecting new or additional data for the database in such a way as to ensure that the information is accurage and up-to-date. It must take into account the amount of data that needs to be collected, and do it efficiently.

These data collection methodologies will depend on the data already available, the extent of the territory, and economic resources available. Therefore, it is recommended that a study be made on the possibility of working together with other areas of the States so that they can all benefit from the collection of this type of information.

In addition to the initial data collection for the creation of the TOD compliant database, ANSP or Aerodrome operator must develop mechanisms for the collection of new or additional data for the database to ensure the information is accurate and current. ANSP or Aerodrome operator must consider how data can be collected in the most efficient and cost saving manner.

For the effective collection of TOD, the following practical steps must be adhered to:

a. roles and responsibilities of all the stakeholders (air navigation services providers, airport authorities, geospatial agencies, etc.) are identified;

b. working methods among the stakeholders are formalized;

c. competent resources are provided, especially in the transition to digital data environments: specific technical expertise is required, mostly with respect to verifying and validating the data;

d. all interaction with the data are recorded for traceability; and

e. sufficient metadata is provided with the originated data, to facilitate its verification and validation.

The data collection is facilitated by the use of the aeronautical data catalogue (PANS-AIM, Appendix 1, Tables A1.6; A1.8 and A1.9) which contains a common data description for the data elements and data quality requirements.

The data types also allow the aeronautical data catalogue entries to be concise and easy to read. For example, the data type “point” of the horizontal position of an obstacle means that latitude, longitude, horizontal reference system and the accuracy information of the obstacle have to be collected.

The organization responsible for collecting and providing data must have key technical personnel such as:

- An engineer cartographer;
- An engineer specializing in aerial photo processing;
- A topographical engineer for field measurements (checkpoints);
- An engineer specialized in GIS (Geographic Information System);

- A Computer Aided Drafting (CAD) technician.

2.1.3. DATA ACQUISITION

In case of existing data doesn't meet the requirement of ICAO and the ANSP/Aerodrome operator choose to get quality data by survey, the survey requirements for the four areas, including resurvey intervals, should be defined, and the common survey formats to be used by surveyors and geodetic institutions should be determined for each of the areas.

The ANSP/Aerodrome operator should consider how surveyors may be monitored to ensure that they adhere to appropriate standards. To this end, any data acquisition should at least be based on the definition of the terms of reference (ToR).

The ToR must contain at least:

- Specifications of terrain and obstacle data;
- Authorization of the data collector or surveyor;
- Competence of the people in charge of data collection;
- Nature of the data to be collected;
- Data transmission support;
- Working methods
- Etc.

The specifications of terrain and obstacle data acquisition is content in template of terms of references of terrain and obstacle data collection.

The standards to be applied by the surveyors, for example the feature capture rules, should be agreed and defined by the CAA and documented. The feature capture rules should be kept as simple as possible. It must be ensured that there is little room for interpretation so that aviation and survey specialists have a common, harmonised understanding.

The following surveying techniques could be used for TOD acquisition

- Conventional Terrestrial Survey
- Aerial Photogrammetry
- Airborne Laser Scanning (ALS), also known as Light Detection and Ranging (LiDAR)
- Interferometric Synthetic Aperture Radar (iFSAR/SAR)

All survey work shall be carried out by appropriately qualified surveyors.

All surveying techniques presented are compared, using different criteria. This comparison will provide recommendations as to which methods are most suitable, under which circumstances, for an organisation. The most important factors to consider are:

- **ALS:**
  - Has very high capital costs and is therefore less widely available,
  - DTM can be extracted almost entirely automatically,
  - Terrain data acquisition is performed almost at no extra cost when combined with obstacle mapping,
  - Has a low risk of missing an obstacle during data acquisition.
- **SAR:**
  - There are only a few providers available due to the highest capital costs and proprietary processing software of all the techniques,
  - The efficiency of data acquisition is high, but is influenced by the need for marked and surveyed corner points,
  - For raw measurements, the penetration level is unclear, which impacts quality in forested areas,
  - SAR is independent from day/night and can collect through clouds,
  - Obstacle extraction from SAR generated digital surface models suffers from low reliability,
  - Global data sets are available.
- **Aerial Photogrammetry:**
  - Is the most efficient technique for data acquisition,
  - The degree of automation is smaller when compared to ALS but the algorithms are still evolving,
  - The imagery can be used as a basis for many other applications,
  - Involves a higher risk of missing an obstacle compared to ALS, but due to manual interaction the quality of the resulting obstacle is expected to be higher than all other techniques.
- **Satellite Photogrammetry:**
  - Same aspects as for aerial photogrammetry plus,
  - Very useful for large areas.
- **Terrestrial survey:**
  - Has the lowest capital costs but is very labour-intensive,
  - Results in a well-structured terrain model (points, breaklines), with a minimum of objects,
  - Is a mature technique, but little further improvement is expected,
  - Is ideal for data validation.

2.2. DATA VALIDATION AND VERIFICATION

The organisation responsible for the validation and verification of data should be identified and mandated.

An assessment should be made to identify if any means to validate data, including metadata, already exist. Means should be identified and, if necessary, defined for the validation and verification of both new and existing data. The verification and validation will be assessed according the ToR criteria for new data.

In addition, an assessment should be carried out to determine the suitability of existing data and how its quality can be verified and validated. It is highly likely, especially when choosing to use legacy data, that full compliance with the requirements of ICAO will not be achieved.

2.2.1. VALIDATION METHODS

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.

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.

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.

More methods of data validation and verification data are addressed in detail in AFI AIM RBIS TOD procedure for Verification and validation TOD.

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

2.2.2. METADATA

The metadata is an important source of information for the verification, validation and understanding of the data. The metadata can be distributed as structured data (based on ISO Standards 19115 and 19139) or be provided as textual information in the quality report.

Some metadata may originate from another Authorised Source further back in the aeronautical data chain, such as survey data provided to an aerodrome operator prior to submission of the survey data by the aerodrome operator to the AISP. The original metadata shall be retained at all stages of data management and final submission to the AISP.

2.3. MANAGEMENT AND PROVISION

2.3.1. DATA PROVISION

The organisation responsible for the provision of data to next intended users should be identified and mandated, e.g. AISP, National Geodetic Agency, aerodrome operator. This organisation is in charge of the provision to the next-intended users, including the formats to be used and the means and media whereby the electronic terrain and obstacle data could be made available.

The contact details of this organization shall contain at least:

- name of the service or organization;
- street address and e-mail address of the service or organization;
- telefax number of the service or organization;
- contact telephone number of the service or organization;
- hours of service (time period including time zone when contact can be made);
- online information that can be used to contact the service or organization; and
- supplemental information, if necessary, on how and when to contact the service or organization.

During the implementation process, consideration should be given to the adoption of interoperable exchange formats for terrain and obstacle data. Additionally, the means by which terrain and obstacle data will be made available to users should be determined.

There are different possible methods for making this data available:

- Data is made available for the user as a SWIM compliant service: data which may be requested through web services as needed, and on-going real-time feeds of messages (notifications or actual data).
- Data is made available for the user by other means over the Internet as File Transfer Protocol (FTP), website, email; and
- Data is provided to the user as a dataset on physical media as CD/DVD or reusable media.

Obstacle datasets will be automatically imported by AIM to AIXM 5.1, removing the need to make manual amendments to their obstacle data.

Aerodrome operators are encouraged to adopt the AIXM 5.1 format for their Master obstacles. All parties in the data chain are required to exchange data using electronic means.

2.3.2. DATA MAINTENANCE

The organization responsible for data maintenance for each specific coverage area should be identified and mandated.

The contact details of this organization shall contain at least:

- name of the service or organization;
- street address and e-mail address of the service or organization;
- telefax number of the service or organization;
- contact telephone number of the service or organization;
- supplemental information, if necessary, on how and when to contact the service or organization.

A monitoring policy should be developed for each aerodrome/heliport which lays down the approach to be taken to ensure that the terrain and obstacle data is maintained in such a way as to give a sufficiently high degree of confidence that it correctly reflects the current situation. It is recommended that this monitoring policy be applied on an individual aerodrome/heliport basis and agreed with the national regulator.

It should outline:

- The regions around an aerodrome/heliport to which different approaches to maintenance and monitoring may be applied;
- For each region, the approach to maintenance and monitoring that will be employed.

This policy may be included with the obstacle permission policy or the aerodrome safeguarding policy in a single document or may be a separate document. The choice of whether to have two policies or a joint one may be dependent upon the chosen responsibilities for monitoring and surveying terrain and obstacle changes as well as on the periodicity situation outlined above.

The following provides examples of how terrain and obstacle maintenance and monitoring may be established:

- No maintenance:

It is considered that the chances of terrain changing sufficiently and/or of an unknown obstacle of sufficient size to impact flight operations being erected are very minimal.

- Occasional inspection:

It is considered that the chances of terrain changing sufficiently and/or of an unknown obstacle of sufficient size to impact flight operations being erected are minimal and, therefore, only occasional assessment, by visual means, is sufficient.

- Frequent monitoring:

It is considered that the chances of terrain changing sufficiently and/or of an unknown obstacle of sufficient size to impact flight operations being erected is significant and, therefore, assessment on a frequent basis is required.

TOD maintenance methods are specified in AFI AIM RBIS TOD Database management and exchange.

2.3.3. ERROR PREVENTION, DETECTION, AND HANDLING

AISP and aerodrome operators should establish and maintain:

- validation and verification processes to ensure that data is acceptable for its intended use and has not been corrupted by the data process;
- digital data error detection techniques and authentication process for any data transfer;

- independent verification of manually inputted aeronautical data (if any) to detect any errors that may have been introduced;
- mechanism to ensure the currency of the TOD within their responsibility (maintenance of data);
- process of monitoring relevant TOD promulgated by AISP;
- mechanisms to report to AIS, with minimum delay changes to data items within the responsibility of the Authorised Source (standard updates or identified errors);
- data error detection and handling process;
- records of identified data errors and the consequential corrective measures taken for errors identified after data delivery to AIS.

All parties shall ensure that error detection and authentication, reporting, measurement, and corrective actions mechanisms are established, maintained, and included in the Management System.

All errors, inconsistencies and anomalies detected in any TOD published by AIS should be reported to AISP.

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.

2.3.4. MAINTENANCE OF DATABASES

Terrain and obstacle databases shall be updated to account for errors that have been uncovered as well as to change appropriate data (e.g. due to construction activities or vegetation growth), so that the applications supported by the use of the databases have continued airworthiness.

According to ICAO Annex 15, obstacle data should be updated in accordance with the AIRAC cycle amendment schedule.

Changes that occur within this period may be provided by NOTAM, data link, or an equivalent method. The method of informing the user of changes depends on the operational use of the data.

There is no specific ICAO update cycle specification for terrain data. Terrain databases shall be updated in accordance with their intended use.

2.4. PUBLICATION OF TOD

2.4.1. ANNOUNCEMENT OF THE TOD AVAILABILITY IN THE CONTENTS OF THE AIP

According to ICAO PANS-AIM Appendix 2 “Contents of the Aeronautical Information Publication (AIP)” the availability of terrain and obstacle data sets has to be announced in the national AIP in section GEN 3.1.6:

“**GEN 3.1.6 Digital data sets**

Description of the available data sets, including:

1. data set title;
2. short description;
3. data subjects included;

4. geographical scope; and
5. if applicable, limitations related to its usage.
6. Contact details of how data sets may be obtained, containing:
   a. name of the individual, service or organization responsible;
   b. street address and e-mail address of the individual, service or organization responsible;
   c. telefax number of the individual, service or organization responsible;
   d. contact telephone number of the individual, service or organization responsible;
   e. hours of service (time period including time zone when contact can be made);
   f. online information that can be used to contact the individual, service or organization; and
   g. supplemental information, if necessary, on how and when to contact the individual, service or organization."

The description according to items 1) to 6) is considered insufficient for users to understand the full content of an available dataset. Therefore it is recommended that in addition to the items specified in ICAO PANS-AIM Appendix 2, GEN 3.1.6 should also provide a link to the Data Product Specifications on which basis air navigation users will be able to evaluate the products and determine whether they fulfil the requirements for their intended use (application). GEN 3.1.6 can also provide a link direct to the dataset or an online platform hosting the dataset (if available) in point 6(g).

In addition to the announcement on the availability of TOD data sets in GEN 3.1.6, it may include:

- An indication in ENR 5.4 that a list of obstacles affecting air navigation in Area 1 is available in electronic form, and a reference to GEN 3.1.6 (mandatory if the obstacle tables are omitted).
- An indication in ***AD 2.10 and ***AD 3.10 that Obstacle Data for Area 2 and 3 is available in electronic form, and a reference to GEN 3.1.6 (mandatory if the obstacle tables are omitted).
- An indication in the Aerodrome Obstacle Charts of the availability of Area 2 electronic terrain and/or obstacle datasets and a reference to GEN 3.1.6.
- An indication in the Precision Approach Terrain Chart (PATC) of the availability of Area 4 TOD and a reference to GEN 3.1.6.

2.4.2. PUBLICATION OF OBSTACLES AS POINTS, POLYGONS AND LINES

In accordance with TOD requirements, an obstacle type should be defined for each obstacle. For individual obstacles (points), commonly known types such as "*wind turbine", "chimney", and "mast"* should be used in the AIP as obstacle types.

For obstacles with geometry other than points (e.g. grouping of obstacles), the common types representing lines and polygons (area) such as *wind farm", "wind plant", "cableway", "power line*" should be used in the AIP, accompanied with (*area)*, (*line)* or (*polygon)* to support the described location (coordinates) of the obstacle.

2.4.3. PUBLICATION OF GROUPS OF OBSTACLES WITH SIMILAR HEIGHT LOCATED IN CLOSE PROXIMITY TO ONE ANOTHER

As general publication guidelines, each obstacle collected is published individually and include the required information as follows

(1) obstacle designator (location or name);

(2) obstacle identifier (a unique alphanumerical sequence) for each separately published obstacle;

(3) type of obstacle;

(4) obstacle position, represented by geographical coordinates in degrees, minutes and seconds;

(5) obstacle elevation and height to the nearest metre or foot;

(6) type and colour of obstacle lighting (if any).

To indicate that the individual listed obstacles are part of a group, the *(3) obstacle type* may be published commonly for the obstacle group. Required information *(2, 4, 5 and 6)* is published for each individual obstacle.

Guidelines for a published area for a group of obstacles within similar elevation:

- The *obstacle designator* (location or name);
- The *obstacle identifier* (a unique (alpha)numerical sequence) concerning a group of obstacle allowing easy reference;
- The *obstacle type* is followed by the word "a*rea"* within brackets (area), to indicate that it is an area;
- The elevation of the area is encompassing the highest obstacle in the group.
- The number of objects included in the area may be published together with the *obstacle type;*
- The area is described with coordinates (latitude/longitude), separated by a hyphen, and where the first and the last coordinate is the same;
- A circle with a centre coordinate and radius can also be used to define the area.

Guidelines for publication of obstacles as a line:

- The obstacle designator (location or name);
- The obstacle identifier (a unique (alpha)numerical sequence) concerning a group of obstacles represented linearly;
- The obstacle type is followed with the word "line" within brackets (line), to indicate that it is a line;
- The line is published by at least 2 coordinate ordered pairs (latitude/longitude), defining as a minimum the end-positions (points) of the obstacle-line;
- The elevation and height is published for each published mast/pole position;
- The maximum height for each portion of the cable/line in between the consecutive poles/masts is published.

2.4.4. PUBLICATION OF OBSTACLES AS A POLYGON

In cases where an obstacle such as a large building or a moving obstacle is published as a polygon and not as a point, the following publication guidelines apply:

- The polygon is described with coordinates (latitude/longitude) separated with a hyphen, where the first and the last coordinate is the same.
- The published elevation/height of the polygon is encompassing the highest position of the obstacle.

2.5. COSTS

The availability and provision of TOD will generate expenses and it is necessary to define a mechanism to cover these expenses.

For cost calculations, a set of elements must be taken into account and specifically analysed by TOD stakeholders based on a series of parameters:

- the extent of its territory,
- the existence or absence of previous terrain and obstacle data,
- the methodology to be used for capturing information,
- the environment around the aerodrome.

In addition to these parameters, consideration shall also be given to the way in which new information will be collected in the future.

In case of outsourcing, the cost of training and the possible signing of an SLA clearly specifying the required data shall also be taken into account.

Accordingly, TOD stakeholders must analyze how they will recover their investment. Some mechanisms are listed below by way of example:

- payment for using the information whenever the database is queried,
- an initial payment for the right to use the information and a fixed annual charge for such use,
- other options that may consider appropriate

2.6. MONITORING/AUDIT OF IMPLEMENTATION

In close coordination with the CAA and related TOD stakeholders, ANS Providers and Aerodrome Operators shall analyzed the current environment and develop a plan/roadmap demonstrating the feasibility of achieving the necessary steps to enable the collection (where applicable), management and provision of electronic terrain and obstacle data in accordance with the national TOD policy.

The implementation planning should cover the following topics, as applicable:

- System change;
- Change management;
- Process development;
- Migration of processes and data;
- Data validation and verification;
- Financial and human resources;
- Performance monitoring;

- Risk management;
- Compliance management;
- Training.

ANNEX A: FEATURE CAPTURE GUIDANCE

This section provide the feature capture guidance should be a deterministic, application-independent and unambiguous guidance on how a real-world object is abstracted and captured as a database feature, whilst fulfilling the quality requirements.

1. POINT OBSTACLE WITH EXTENT

An obstacle represented by a single point is the most common case in the obstacle data provided today. For obstacles with a considerable relevant footprint as opposed to antennas or poles with a neglectable horizontal extent, the knowledge of the size of this footprint is relevant for the user's operations. In these cases, the horizontal extent of the point obstacle should be captured. The following examples illustrate typical cases where a radius sufficiently describes the horizontal extent.

If the horizontal extent exceeds a certain threshold, either in width, length or both, then a polygon or a line is a better geometric representation for the obstacle than a point with a radius.

1.1. WIND TURBINES

A wind turbine is an obstacle with moveable parts, i.e. the blades. For determining the maximum elevation (height) and horizontal extent of the obstacle, the size of the rotor blades has to be taken into account (see Figure A1).

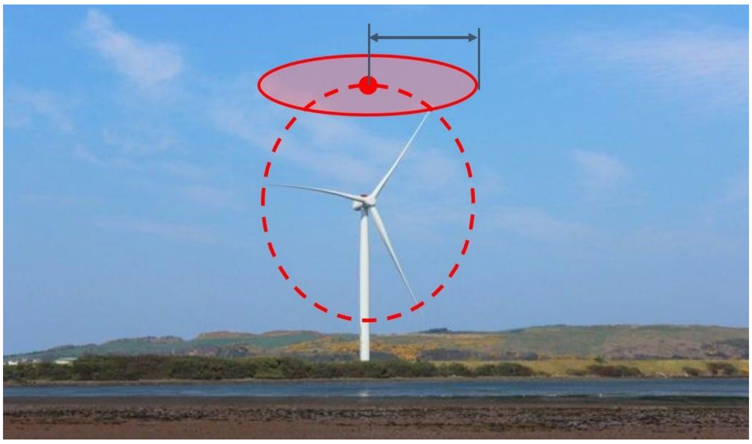

Figure A1: Capture of the relevant elevation and extent of a wind turbine

1.2. CRANES

A crane is an obstacle with a moveable part, i.e. jib. For determining the obstacle, the radius of the jib is captured as well as the maximum point of the crane. The figure below shows such an example.

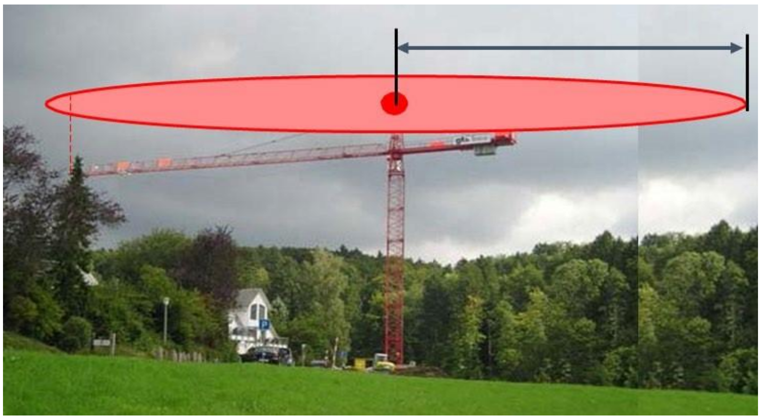

Figure A2: Capture of the relevant elevation and extent of a crane

1.3. MASTS WITH GUY WIRES

It is important to capture the horizontal extent of a mast at the relevant footprint with guy wires since the wires are not visible to a VFR pilot. Figure A3 illustrates a mast that is captured as a point with a radius. In case where the guy wires exceed the threshold value for a point obstacle for specific area a polygon obstacle would be more appropriate.

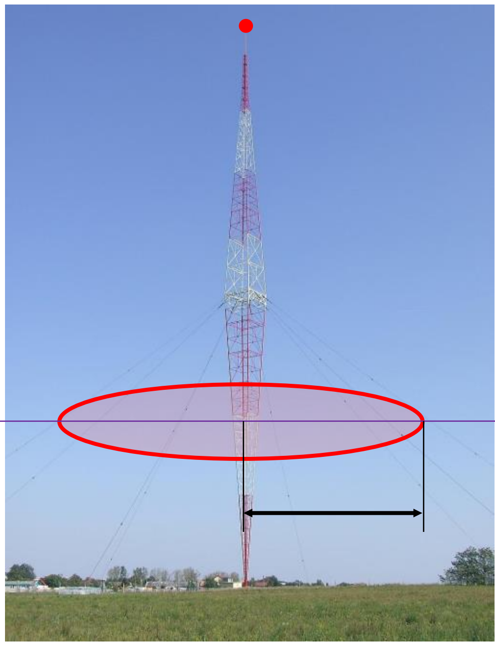

Figure A3: Capture of the relevant elevation and extent of a mast with guy wires

2. GROUPING OF OBSTACLES

Adjacent point obstacles of similar height and elevation can be grouped into an obstacle of type polygon or line. The decision if the objects are captured as single obstacle or as a group depends on the operational needs e.g. if operations are planned or not between obstacles.

2.1 WIND PARKS

A wind park consisting of a group of wind turbines can be represented as a polygon, a line or a set of multiple individual obstacles as in the figures below.

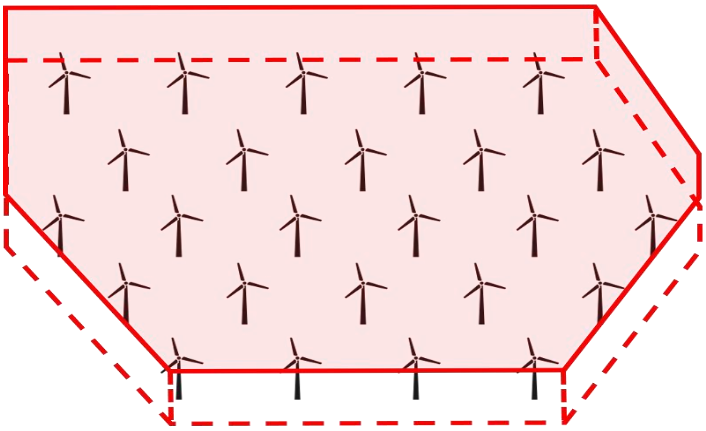

Figure A4: Capture of a wind farm as a polygon

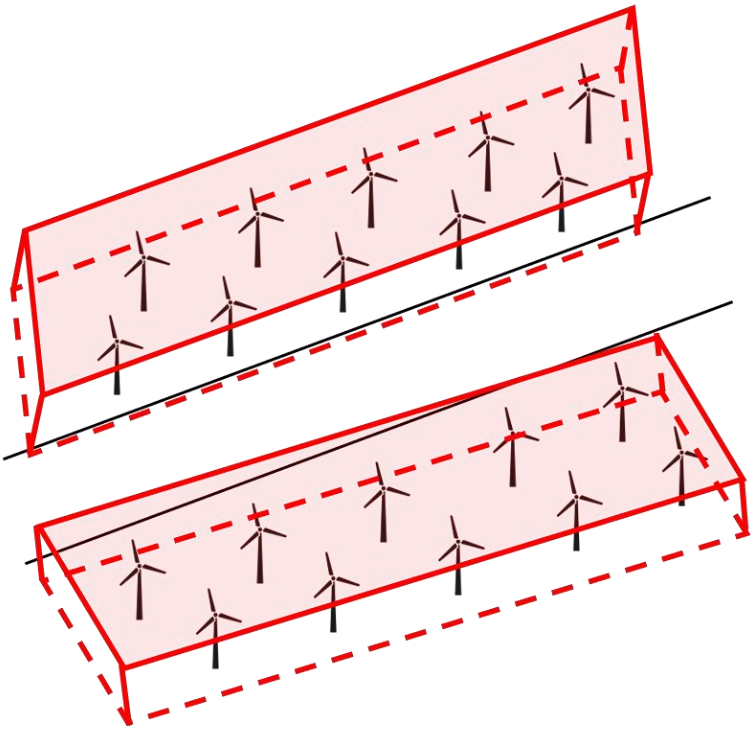

Figure A5: Capture of wind park with space for potential helicopter operations

Wind turbines positioned in a line may be collected as a line and a horizontal extent (in width) as in Figure A6 below.

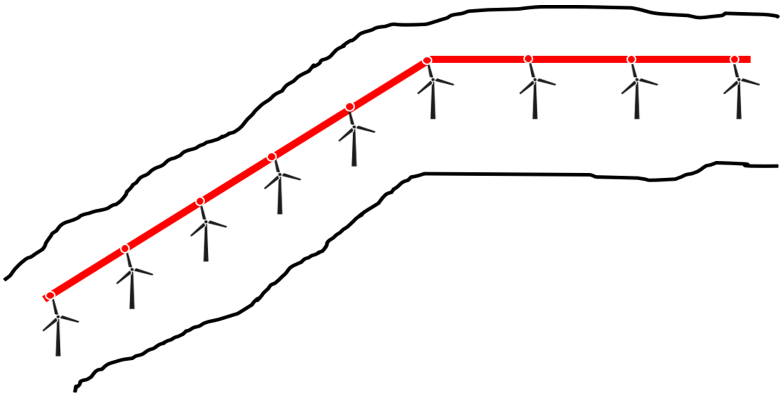

Figure A6: Capture of a wind farm as a line

There may be an operational benefit to collect and represent each individual wind turbine of a wind park as a single obstacle. For example, if flight operations can occur within a wind park (e.g. helicopter rescue operations at a crossing road), then the collection of each individual wind turbine may be the preferred method to accommodate the flight operations.

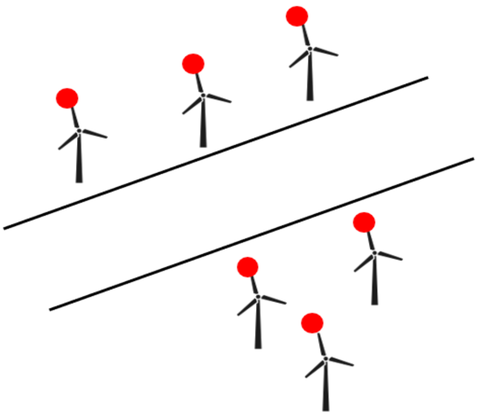

Figure A7: Capture of wind turbines as individual points

2.2 STREETS – LIGHT POLES ALONG A HIGHWAY

Light poles along a highway in the approach / take-off area can be captured as a line and a horizontal extent.

Figure A8: Capture of light poles along a highway as a line

3 OBSTACLE WITH CABLES

Obstacles with cables mounted on poles and masts like power/transmission lines, cable cars etc. are broken into parts following the principle: point – line – point – line – point and so forth, as exemplified in the figure below.

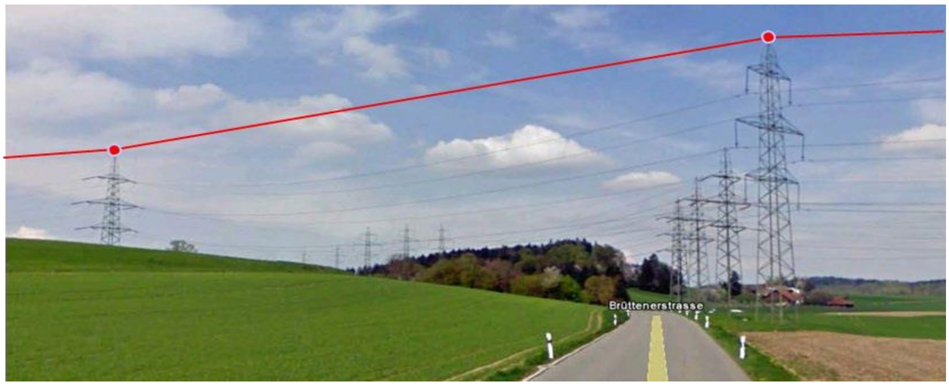

Figure A9: Principle of capturing power lines

3.1 POWER LINE NETWORKS

Power/transmission lines often form a network (see Figure A10). There are different possible ways how to structure the parts (P: poles and cables) into obstacles (O):

a) Each segment between branching or terminating nodes is a separate obstacle: O1 = {P1, P2, P3, P4, P5}

   O2 = {P5, P6, P7, P8. P9}

   O3 = {P5, P10, P11, P12, P13, P14, P15}

b) All segments belong to the same obstacle:

   O1 = {P1, P2, P3, P4, P5, P6, P7, P8. P9, P10, P11, P12, P13, P14, P15}

c) One main line is one obstacle; the branch is a separate obstacle: O1 = {P1, P2, P3, P4, P5, P6, P7, P8. P9}

   O2 = {P5, P10, P11, P12, P13, P14, P15}

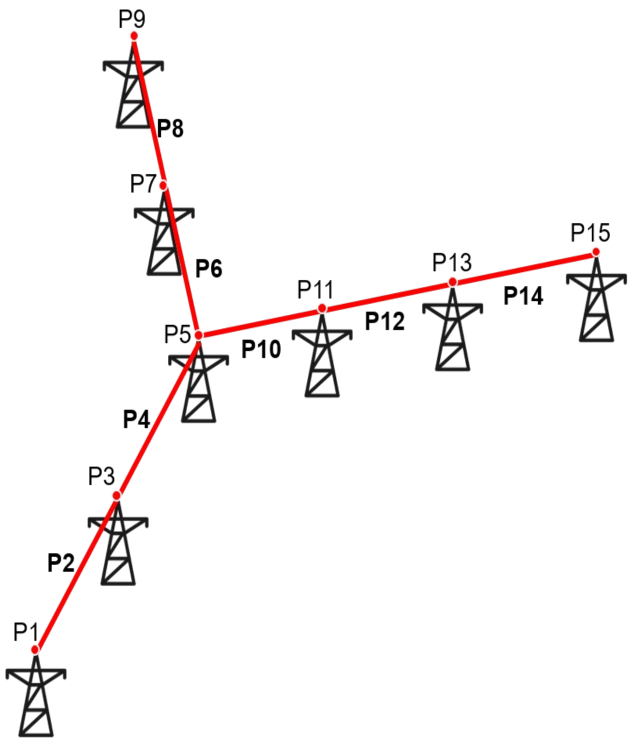

Figure A10: Capture of power line networks

3.2 POWER LINES WITH SECTIONS BELOW THE COLLECTION SURFACE

The figure below illustrates the cases how the power lines with sections below the collection surfaces should be captured assuming an obstacle data collection surface is 100 m AGL.

Example 1) presents the capture of a power line with poles higher than the collection surface (e.g. 120m) and a section with poles below the collection surface (e.g. 45m) at the end of the line. The capture stops after the last part intersecting collection surface.

Example 2) presents the capture of a power line with a section of less than ten poles below the collection surface in the middle of the line. To preserve the continuity of the obstacle line all parts are captured regardless of their height.

Example 3) presents the case of a power line with a section of more than ten poles below the collection surface in the middle of the line. The continuity of the obstacle line is not considered and thus, the intermediate section is not captured.

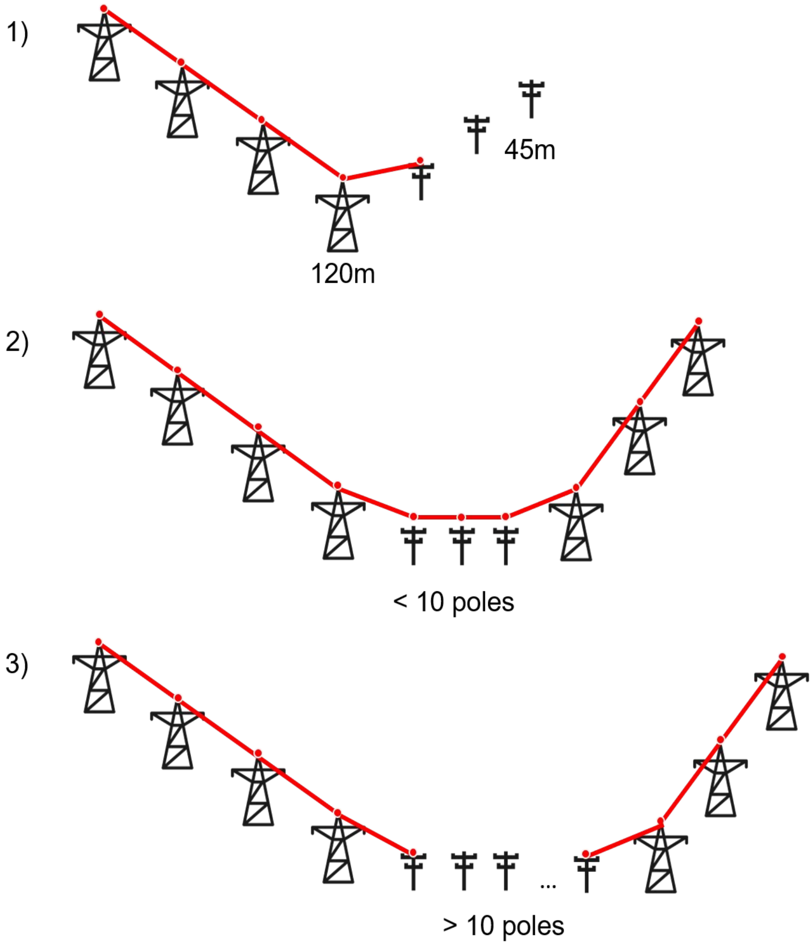

Figure A11: Capture of power lines with segments below the collection surface

4. MOBILE OBSTACLES

Mobile obstacles (objects that penetrate the obstacle collection surfaces without a fixed location) occupy a larger piece of airspace than their spatial extent. The total perimeter in which they can be located has to be taken into consideration when capturing mobile obstacles.

4.1. RAIL MOUNTED GANTRY CRANE

Rail mounted cranes such as a gantry crane (first picture below) or a container crane in a harbour can move in a limited area defined by the rails. A rail mounted gantry crane is captured considering the height and the maximum area of movement, which defines the footprint of the obstacle (second picture below). Then, the relevant footprint of the object is considered taking into account the penetration of the collection surface.

Figure A12: Capture of a rail mounted gantry crane

4.2. SHIPS AND ROADS

Ships and roads in the approach / take-off area of an airport can be mobile obstacles if they penetrate the obstacle limitation or collection surfaces. Such an obstacle is captured as a polygon considering the maximum height of the ships using the waterway and the boundary of the part of the waterway relevant for the operation.

A similar and probably more frequent case is a highway with trucks penetrating the Area 2b (or Area 4 or the take-off flight path area) surface of an airport.

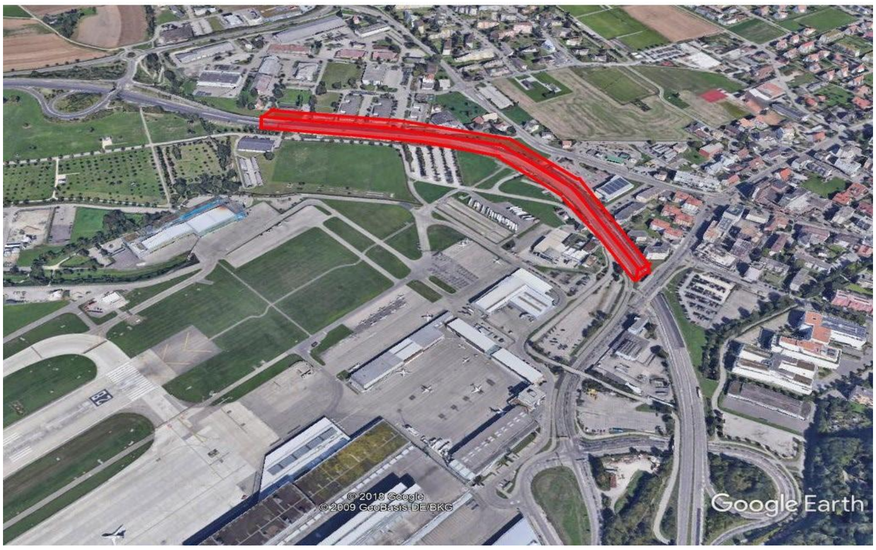

Figure A13: Trucks on a highway are mobile obstacles in the approach area of a runway

5. BUILDING WITH COMPOUND STRUCTURES

The size of the relevant footprint varies, in many cases, with growing height (trees, tilted roofs, ontop structures, nested buildings or roof mounted antennae). In several cases, the application of the footprint and the maximum height may not be favourable in cases where the object is described as much bigger than the real-world object. Such objects may impact the obstacle clearance and thus, the operational purposes.

It should be noted that in most cases vertical segmentation is not necessary and it is suffcient to capture an object as a single point obstacle – if required with a horizontal extent (see section 1). Vertical segmentation can be useful for operational gains, e.g. if the obstacle is located close to an instrument flight procedure or obstacle limitation surface and if valuable airspace can be gained by spliting the obstacle in several parts of different dimensions.

A typical example is shown in the figure below. The obstacle composed of two parts (the building P1 and with an antenna mounted on top of it P2) requires the structure to be "sliced" horizontally based on the maximum allowed footprint size for the initial geometry. This results in two segments being stacked on top of each other and therefore, segmented to avoid using the relevant footprint for the entire height of the obstacle.

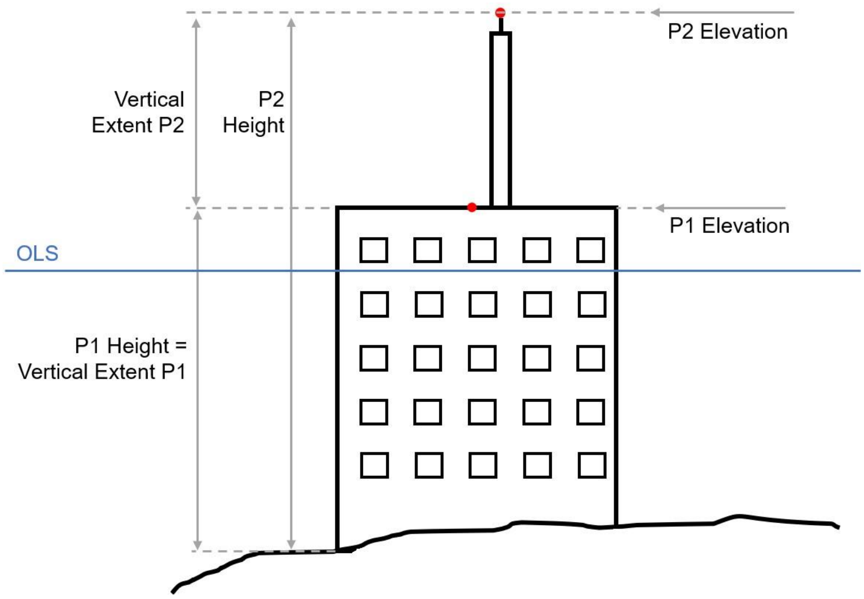

Figure A14: Example of a segmented obstacle

When obstacles are captured by airborne methods like photogrammetry, satellite imagery or LIDAR, the heights can only be derived by calculating the difference between the elevations of the obstacle and the ground or of the obstacle underneath (P1 and P2, in the example figure). The calculation of reliable heights requires the application of the same survey method (e.g. LIDAR) for the determination of the ground and obstacle elevation.

6. VEGETATION

6.1. FORESTS AS PART OF A TERRAIN DATA SET

The terrain data set can be a so-called bare earth model, describing the continuous surface of the ground without any man-made objects and vegetation or include the forests or other vegetated areas. Forests which cannot, due to their size, be modelled as point or line features must be added to the terrain set on top of the bare earth. In such cases, it should be ensured that the vegetated area is collected as a first reflective surface. Where this is not achievable due to sensor constraints, the penetration level must be stated, based on control surveys.

6.2. ISOLATED FORESTS AS OBSTACLES

Isolated forests are usually captured as a polygon obstacle. The construction of a forest obstacle should be based on the maximum elevation calculation. However, a single forest area with the maximum elevation is obviously too stringent especially if the forest is covering a hill. As a result, it is recommended that in addition to the polygon tree points are captured as single points with a proposed density of tree points (e.g. 1 tree per 10 ha). Density will depend on whether the terrain is flat. Local maxima could be used when data is captured by LIDAR.

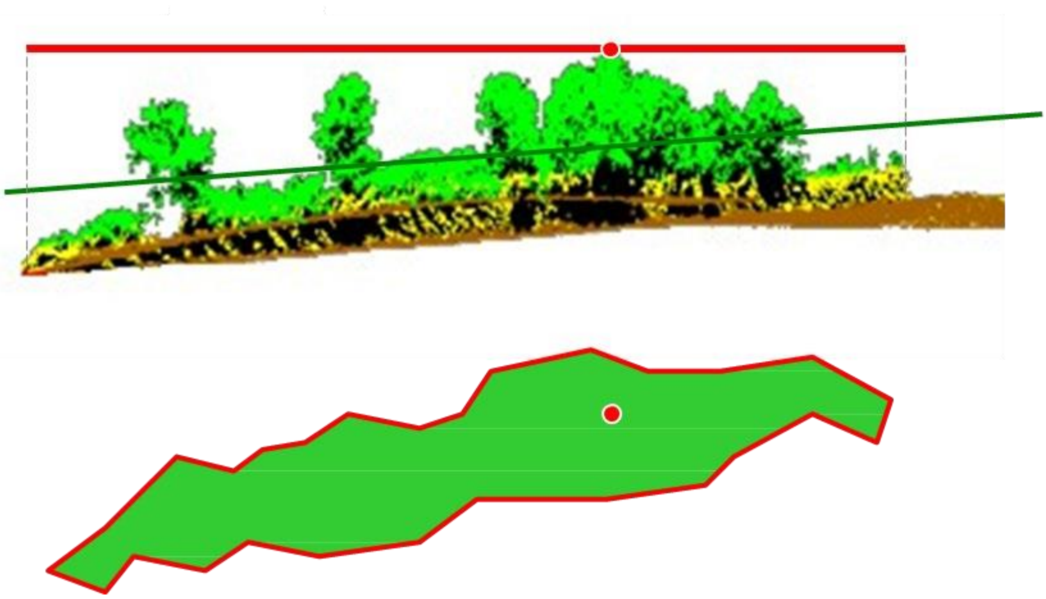

Figure A15: Capture of a forest as a polygon

ANNEX B: IMPLEMENTATION TOD CHECKLIST

N°	CHECKLIST QUESTIONS	EVIDENCES	COMPLIANCE			OBSERVATIONS
			S	NS	NA	
	IDENTIFICATION OF SOURCES OF DATA					
1.	Are data sources identified ?		☐	☐	☐	
2.	Does the points of contact for each source are identified?		☐	☐	☐	
3.	Does data sources are awareness about TOD requirements?		☐	☐	☐	
4.	Working methods among the stakeholders are formalized?		☐	☐	☐	
5.	**TRAINING**					
6.	Have you developed a training program and the documentation for TOD stakeholders and focal points?		☐	☐	☐	
7.	Have you conducted training program?		☐	☐	☐	

8.	Have you conducted seminars for TOD specialists, setting forth the plans and the operational and economic benefits expected?		☐	☐	☐	
9.	**DATA COLLECTION**					
10.	Is there the terrain and obstacles data available?		☐	☐	☐	
11.	Is an assessment carried out to determine the suitability of existing data and how its quality can be verified and validated?		☐	☐	☐	
12.	Are formal arrangements established between the data provider and AISP for TOD collection?		☐	☐	☐	
13.	Is the aeronautical data catalogue (PANS-AIM, Appendix 1, Tables A1.6; A1.8 and A1.9) used to TOD collection?		☐	☐	☐	
14.	Are these data are meet data quality requirements?		☐	☐	☐	
15.	Mechanisms for the collection of new or additional data for the database to ensure the information is accurate and current has been defined?		☐	☐	☐	
16.	**DATA ACQUISITION**					
17.	If these terrain and obstacle data are not meet data quality requirement, are you planned to get quality data?		☐	☐	☐	

18.	Are the survey requirements for areas, including resurvey intervals defined?		☐	☐	☐	
19.	Have you defined the technical and logistic specifications of the project?					
20.	Are the common survey formats to be used by surveyors and geodetic institutions determined for each of the areas?		☐	☐	☐	
21.	**FINANCIAL ANALYSIS**					
22.	Have you estimated the general cost of the project?		☐	☐	☐	
23.	Have you prepared the financial documentation?		☐	☐	☐	
24.	Have you submitted the final document to top management for approval?		☐	☐	☐	
25.	**METADATA**					
26.	Are terrain and obstacle data transmitted with metadata?		☐	☐	☐	
27.	Are the original metadata retained at all stages of data management?		☐	☐	☐	
28.	**DATA PROVISION**					
29.	Is the organization responsible for the provision of TOD to next intended users identified and mandated?		☐	☐	☐	

30.	Are the means by which terrain and obstacle data made available to users determined?		☐	☐	☐	
31.			☐	☐	☐	
32.	**DATA MAINTENANCE**					
33.	Has a monitoring policy been developed for each aerodrome/heliport which lays down the approach to be taken to ensure that the terrain and obstacle data is maintained?		☐	☐	☐	
34.	Are error mechanisms for detection and authentication, reporting, measurement, and corrective actions established and maintained?		☐	☐	☐	
35.	Does TOD database exist?		☐	☐	☐	
36.	Are mechanisms for using of TOD database established?		☐	☐	☐	
37.	**PUBLICATION OF TOD**					
38.	Have you decided to publish TOD?		☐	☐	☐	
39.	Has an obstacle type defined for each obstacle?		☐	☐	☐	