ICAO RBIS TOD PROJECT

TERRAIN AND OBSTACLES DATA

TERMS OF REFERENCE (TORs) FOR OBSTACLES DATA ACQUISITION TEMPLATE

Doc No. : AFI_AIM_RBIS_TOD_ToR Obstacles_TMP

Statement of Requirements

For

obstacles data acquisition for [aerodromes]

0. DOCUMENT ADMINISTRATION

0.1. APPROVAL PAGE

	Position	Name and Signature	Date
Prepared by			
Reviewed by			
Approved by			

0.2. LIST OF EFFECTIVE PAGES

List of Effective Pages	
Page Number	Revision Date

0.3. RECORD OF AMENDMENTS AND CORRIGENDA

Record of amendments			
Ed.	**Rev.**	**Date of the amendments**	**Reason for the amendments**

Record of corrigenda			
Ed	**Rev**	**Date of the corrigenda**	**Reason for the corrigenda**

0.4. DOCUMENTS REFERENCES

- ICAO Annex 4: Aeronautical Charts;
- ICAO Annex 14 - Aerodromes, Volume l: Aerodrome Design and Operations;
- ICAO Annex 15: Aeronautical Information Services;
- ICAO Document 9881 - Guidelines for Electronic Terrain, Obstacle and Aerodrome Mapping Information;
- ICAO Document 9674 - World Geodetic System 1984 (WGS-84) Manual v11. Standards related to electronic terrain and obstacle data collection;
- ICAO Doc 10066 PANS AIM.

0.5. CONTENTS

1. INTRODUCTION

The need for digital data sets and digitized aerodrome maps was expressed to ICAO by industry and, as a consequence, was included within Amendment 33 to ICAO Annex 15 which was adopted in February 2004 and became effective in July of that year. It was, however, acknowledged by ICAO that the introduction of electronic terrain and obstacle data (TOD) was a challenge and, consequently, the applicable dates for this data were deferred. Area 1 (The State) and Area 4 (CAT II/III Operations Area) became effective on 20th November 2008. The remaining areas, Area 2 (The Terminal Area) and Area 3 (The Aerodrome) became effective on 12th November 2015.

It is because of the above mentioned reasons that **[Organization name]** has budgeted and allocated fonds for the acquisition of terrain and obstacle data for **[list each specific coverage areas]** for **[list of aerodromes]**.

The primary objective of this project is to achieve the following national and international regulations related to terrain and obstacle data for **[list of aerodromes]**.

Digital data covering an area within the radius of 45km centered around the aerodrome Reference Point (ARP) of each of the following **[list of aerodromes]** and subsequent aerodrome mapping (including extraction of DEM, DTM, DSM and generation of contours at appropriate intervals) over the study area indicated below. It is intended that the data collected will be used to generate spatial and non-spatial data/ information of **[list of aerodromes]** to be used for aerodrome mapping, terrain modelling and obstacle mapping for the safe operations of airports and aircraft for each aerodrome.

The acquired digital data/ information shall be use for the following airports and air navigation applications.

For airports:

a) Certification of airports types of operations

b) Determination of maximum take-off weights

c) Update of airport ground movement and control systems e.g. Advanced surface movement guidance and control system (A-SMGCS);

d) Airport planning and land use studies

e) Provision of geodetic control for engineering projects

For air navigation services:

a) Setting up TOD and Aerodrome Mapping databases

b) Aeronautical chart production

c) Update of aeronautical publications

d) Aircraft operating limitations analysis;

e) Update of on-board databases of the flight management systems.

2. PROJECT AREA

For each **[list of aerodromes]** large format images are to be captured over a circular area of approximately 45km centred on the Aerodrome Reference Point (ARP) usually located midway the runway. Preliminary representations of the Areas of Interest (AOI) and tentative lines of flight if applicable alongside detailed/elaborate methodologies on capture and processing of data are to be included in the technical proposals to be provided.

a) To attain the aerodrome data requirement of the Civil Aviation Aerodromes, the project area for the work involves the survey of features or positions (navigation aids and navigation points) of importance to air and ground navigation within a fifteen (15) kilometer radius from aerodrome Reference Point (ARP) of the airports which corresponds to the Outer Horizontal surface, approach and take-off climb surfaces of the aerodrome's Obstacle Limitation Surfaces. A list of possible features or points to be surveyed are provided in the project deliverables and related appendices to this document. ln general, the area to be surveyed is under the obstacle limitation surfaces as listed in ICAO Annex 14 Volume 1 and the Civil Aviation (Aerodromes) Regulations 2019.

b) To achieve the TOD requirements specified in the Civil Aviation (Aeronautical Information Services) Regulations, the area of interest will cover an area within a radius of forty five (45) kilometers from the ARP of the above aerodromes inclusive of the area specified in a) above.

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.

3. PROJECT SCOPE

The scope of the project shall include, but not limited to:

a) Mobilization to/from the work sites;

b) Carry out community sensitizations, whenever necessary, in the areas to be mapped;

c) Supply and positioning of sufficient ground based GPS base stations as required to achieve the specified survey accuracy. As far as practicable, the Aerodrome Reference Point (ARP) shall form part of the GPS base stations;

d) Gaining of all necessary approvals from the relevant aviation authorities, military or other authorities as may be required, for the execution of the project;

e) Capture of the required area (Area 1, 2, 3 and 4), in order to obtain the required point density; swath coverage and digital imagery to meet the product requirements;

f) Processing and formatting of the digital data and maps/charts in accordance with the technical specification requirements described in the referenced documents;

g) Data usage, integration and interpretation Training; the consultant is expected to load the data onto the client's databases, auto generate relevant aerodrome and other mandatory charts, and provide instructions on the use of the data;

h) Processing and formatting of the data in accordance with the technical specification requirements;

i) Delivery of specified products or deliverables especially the survey reports in full compliance with the data quality accuracies, digital data and reporting formats. stipulated in ICAO Doc 9674, PANS-AIM appendix 1;

j) Setting out and Documentation of aerodrome control points (inclusive of the ARP) in compliance with ICAO Doc 9674 specifications

4. GEODETIC PARAMETERS

All results are to be provided in WGS-84 and UTM projection (bearing in mind the relevant zone). An example of which is provided in the table below.

- Geographical Coordinates are provided in WGS-84
- Ellipsoïdal Heights are given above the GRS-80 ellipsoid

Plane Coordinates are expressed in a UTM projection applicable to the relevant zone

Elevations refer to MSL as given by the EGM96 global geo-potential mode.

Table 1: Geodetic parameters

WGS-84/ITRS (ITRF96) Datum Parameters	
Datum	WGS-84 / ITRS
Realization frame	International Terrestrial Reference Frame 2008
Spheroid	GRS80
Demi-Grand axe (a)	6 378 137.000 m
Demi Petit axe (b)	6 356 752.314 m
Eccentricity (e)	0.006 694 380 067
Inverse flattening (1/f)	298.257 222
Projection Parameters	
Nom	UTM Zone xx (specify zone number)
Projection type	Transverse Mercator
Longitude Origin	To be specify (related to state)
Latitude Origin	To be specify (related to state)
Scale factor at Longitude	0.9996

5. PROJECT DELIVERABLES

a) The following are project deliverables expected after the successful completion of the WGS-84 survey that are meant to address the requirements project objective :

i. Set out and monument to establish at least four (04) monumented compliant stations at the end of the project as per the specifications provided in ICAO Doc 9674 Chapter 5 Attachment A, including photographs;

ii. Description and photographs of geographical positions as per the specification provided in ICAO Document 9674 Chapter 5 Attachment B;

iii. Survey Reports, namely:

- Geodetic Connection Report - that details how the connection was made to the WGS-84 geodetic network (Refer to ICAO Doc 9674 Chapter 5 Attachment C and Appendix C);
- Aerodrome Survey Report (Refer to ICAO Doc 9674 Chapter 5 Attachment C);

  Note:
  - *In addition to these reports, records of actual observations must be provided in separate indexed volumes. Cross-references to observations must be made in the survey report.*
  - *All survey observations may be made and recorded to the resolution and accuracy of the equipment used so that future requirements for surveys of greater precision might be met. Where surveys are undertaken using equipment or techniques that yield height data as well as horizontal position, these must be comprehensively recorded and included in the survey report.*
  - *Survey observations of key points such as monuments, runway threshold, stand "T" markings etc. should be photographed to aid identification of exactly the point surveyed.*
- When submitting the report, the surveyor should include details of all obstacles surveyed, whether they penetrate the relevant obstacle limitation surfaces or not;
- The database of obstacles shall show the measurement of intrusion into the relevant obstacle limitation surface, or Type A chart surface, as applicable, and specify for each obstacle the surface that is infringed;
- Fine obstacles such as lightning conductors or aerials that surmount the abject may not be visible over a distance. Therefore, care must be taken when observing distant obstacles to ensure that the highest point is surveyed.

iv. Aerodrome emergency grid reference map for Aerodrome;

v. Safeguarding chart - in accordance with Control of Obstacles guidance (to be put in place);

vi. WGS-84 geographic coordinates and elevations/heights of any features that are of significance to air or ground navigation that are located within the runway or taxiway strips;

vii. Digital Data delivered by the Universal Data Delivery Format (UDDF) to cater for the process of reporting surveyed data to the AIS (Refer to ICAO Doc 9674 Chapter 7 Section 7.3).

viii. Data should also be supplied in Shapefiles, CAD and AIXM 5.1 data format (the exact data base format to be agreed with AIM prior to tender) in addition to UDDF; and Google earth KMZ files containing all obstacles and obstacle limitation surfaces

b) The deliverables that cater for the TOD requirements for this project are summarized in the table 2 below:

Table 2: Summarize of TOD requirements

Description	Attribute	Specification
Survey area in km^2	Km^2	
Equipment to be used (including parameters used in data processing)	All relevant equipment	e.g. Large format digital camera
Colour Imagery	Entire area	GeoTIFF, ECW
Resolution in cm	cm	10
XY - accuracy of images in cm	cm	20
Z - accuracy in cm	cm	10 - 20 in areas without vegetation
Fully processed geo-referenced and ortho rectified aerial photo image files in GeoTIFF format on a hard drive or via ftp account.	For the whole area of coverage	GeoTIFF, ECW
Digital line mapping	3-D	DXF, DGN, Shapefiles, DWG Geodatabase Avitech formats
Topographical maps (both soft and hard copies) Scale The digital maps should be made at scale 1:2500. The consultant shall also carry out the survey in such a way as to enable the production of maps at other scales e.g. 1:10,000, 1:50,000, 1:250,000	1:2500; 1:10,000, 1:50,000, 1:250,000	ESRI Geodatabase, ESRI ArcGIS Map documents, Shapefiles, DXF, DGN, DWG, Avitech SDO topographic database format files Paper size shall vary according to scale, but preferably A0 size
Coordinate System	GCS-WGS- 1984 Datum: D-WGS- 1984 Spheroid: WGS_1984 Geiod: EGM96	Geographical and projected, Ellipsoïdal & Orthometric heights. WGS-84 Manual (ICAO Doc 9674) refers
Monthly progress reports	Both soft & hard copies	Appropriate

Description	Attribute	Specification
Final survey reports	Both soft & hard copies	RINEX/ ASCU; ICAO Doc 9674 WGS-84 Manual report structure
All the raw survey data files and the processed data files shall be delivered to **[Organization name]** including all the processing parameters	Soft and hard copies	ASCII & DXF, Feature Datasets/Classes, Raster/Mosaic Datasets/Catalogs, GeoTIFF, Relationship Classes, SDE Tables, Shapefiles, GeoTIFF, Excel, Relationship Classes, SDE Tables, Shapefiles, ESRI Geodatabase, DGN or DWG, Avitech static data files
Obstacle data sets for areas 2a, 2b, 2c, 2d, 3 and 4, as described in ICAO Annex 15	Soft and hard copies	Excel sheets, AIXM 5.1 (XML) obstacle datasets. For each obstacle provide: obstacle area Obstacle identification or designation; Type of obstacle; Obstacle position, represented by geographical coordinates in degrees, minutes, seconds and tenths of seconds; Obstacle elevation and height to the nearest metre or foot; Obstacle marking, and type and colour of obstacle lighting (if any); Aeronautical Data quality requirements in the Doc 9674 and other relevant documents must be met (section 11)

Description	Attribute	Specification
Obstacles data sets for areas 1, 2, 3 and 4, as described in ICAO Annex 15	Soft and hard copies	Excel sheets, AIXM 5 .1 For each set of obstacles data for area 2a, 2b, 2c, 2d, 3 and 4, provide; Overview, specification scope, data product identification, data content and structure, reference system, data quality, data capture, data maintenance, data portrayal, data product delivery additional information and metadata. Aeronautical Data quality requirements in the Doc 9674 and other relevant documents must be met (section 11)
TOD Airspaces TOD Area 3 airspace block TOD Area 4 airspace block TOD Area 2a airspace block TOD Area 2b airspace block TOD Area 2c airspace block TOD Area 2d airspace block	Soft and bard copies	Excel sheets, AIXM 5.1 (XML) files 3D models 2a, 2b, 2c, 2d, 3 and 4 airspaces
Monumentation	Soft and hard copies	Tabulated WGS-84 coordinates (EGM 96)
Data usage, integration and interpretation Training	Customized hands-on training for 6 AIM personnel	Load TOD into the clients TOD databases

Description	Attribute	Specification
		Produce an aerodrome terrain and obstacle chart as evidence (As specified in ICAO Annex 4 and Document 8697) Provide instruction manuals for loading the terrain and obstacle databases, and loading updates to the data Provide instruction manuals for developing all the charts and aerodrome layouts produced by the consultant and how to update the charts developed

6. PROJECT METHODOLOGY

The consultant will clearly document the project methodology step by step indicating how the project will be executed, the method to use in data capture, acquisition and implementation.

6.1 PROJECT IMPLEMENTATION PLAN REVIEW

The consultant's project implementation plan shall be reviewed with the client to check the work plan and deliverables. Appropriate reference shall be made to the WGS-84 Manual, (ICAO Doc 9674), Electronic terrain and obstacle and aerodrome mapping manual (ICAO Doc 9881) and all reference material indicated in section 16 of these TORs) during the implementation of the entire project.

6.2 PROCESSING OF PERMISSIONS AND CLEARANCES

Clearances from the relevant authorities are necessary for the survey teams. Clearances will be sought from the military, civil aviation authority, the ministry of lands, housing and urban development, and local authorities. To facilitate this process, letters of introduction will be required from CAA.

6.3 COMMUNITY SENSITIZATIONS

Conduct community sensitization and liaison with local authorities all districts affected by the project.

6.4 GROUND CONTROL SURVEY

Ground control survey shall include:

- Location of GCPs
- Monumentation
- GPS Observations
- Processing Coordinate information
- Field and office operations
- Reporting

6.5 DATA CAPTURE AND ACQUISITION

The Consultant shall clearly and extensively document the method of data capture and acquisition clearly elaborating the steps in the methodology and how data will be captured.

6.6. DEFINITION OF OBSTACLES AIRSPACES

The airspaces to be defined are obstacles area 3, area 4, area 2a, area 2b, area 2c, area 2d and area 1 airspace blocks.

6.7 OBSTACLE MAPPING

Digital representation of the vertical and horizontal extent to manmade and natural significant features such as isolated rock pillars and natural vegetation (trees) that are of a particular height.

6.8 FIELD CHECKS/GROUND TRUTHING

Once the draft layouts or maps are ready, the consultant shall carry out ground truthing exercise in order to identify features which are not mapped, and subsequently update the surveyed data

- Samples of the surveyed data (as specified in the section 5) will be sent to **[Organization name]** for verification and analysis at the third meeting with the consultant before the final deliverables are produced;
- The POE should have a qualified staff to oversees the application of techniques mentioned in the Bidder methodology.
- Markings and colours used should be those specified in ICAO Annex 4, Appendix 3.

6.9 HANDS-ON DATA USAGE, INTEGRATION AND INTERPRETATION TRAINING

The consultant shall offer customized hands-on data Usage, Integration and Interpretation training for **six AIM personnel**

a) Load data into the clients databases, and generate aerodrome terrain and obstacle chart - ICAO, terrain dataset, and obstacle dataset

b) Develop and deliver user instructions

c) Train at least six AIM users

7. QUALIFICATIONS OF THE CONSULTANT

7.1 LEAD CONSULTANT

7.1.1. OVERALL QUALIFICATIONS

To qualify for award of the Contract, bidders shall meet the following minimum qualifying criteria:

(a) Experience as prime contractor of a similar aviation project in African region

(b) Experience as prime contractor in the provision of at least two projects of a size and nature equivalent to this over the last 5 years (to comply with this requirement;

(c) Proposals for the timely acquisition (own, lease, hire, etc.) of the essential equipment

(d) a Project Manager with five years' experience in projects of an equivalent nature and volume, including no less than three years as Manager;

Site Visit: The Bidder, at the Bidder's own responsibility and risk, is encouraged to visit and examine the sites of required services and its surroundings and obtain all information that may be necessary for

preparing the Bid and entering into a contract for the Services. The costs of visiting the Site shall be at the Bidder's own expense.

7.1.2. COMPANY REQUIREMENTS

a) The Bidder shall have a modern digital equipment, software and technology to carry out a colour digital aerial photography, data processing, aerial triangulation, digital terrain model extraction and production of the digital ortho-rectified imagery.

b) The Bidder shall have at minimum 15 years of experience working in the aerial photography and digital mapping including at minimum 10 years of experience of similar nature projects in Africa. The experience implementing aerial photography projects other Africa countries with similar environment and climate conditions, knowledge of security, requested permits and clearances procedures etc. will be considered as an advantage.

c) The Bidder should be financially strong to carry out the project of similar nature and complexity in tropical environment, infrastructure and climate conditions of the Sub-Saharan Africa and provide the documentary evidence of its financial status and stability during last five years.

d) The Bidder should provide the confirmation and documented evidence of the successful completion of similar projects in equatorial and/or desert conditions and in neighboring countries. The evidence of such project's completion during last ten (10) years in Africa will be an advantage.

7.1.3. MINIMUM EQUIPMENT REQUIREMENTS

The Bidder shall provide document evidence confirming that it has the minimum equipment as follows:

- A minimum of two (2) Specialized Aircrafts for aerial photography that comply with the requirements;
- At least Two (2) medium - large format Digital Aerial Cameras with the calibration certificates that expire not earlier than estimated end of aerial photography works;
- Industry standard navigation and flight management system such as for each set of aerial cameras as per requirements;
- GPS and other equipment certified for the aerial photography - a minimum of two sets of equipment as per requirements of the project;
- Software and Equipment for Aerial Triangulation as per requirements and specifications of the project;
- Software, Equipment for the Digital Terrain Model and Digital Ortho-rectified Imagery production and human capacity to complete such production within the time specified in the Project Schedule and as per requirements and specifications of project;
- GPS equipment (dual frequency receivers) for surveying of the GCPs and additional control points as well as reference stations for the aerial photography according to the specifications

and requirements of the project work in the quantities necessary for the completion of the project blacks as per requirements of the Project Implementation Schedule;

- The Bidder shall present the registration documentation, recent maintenance certificates for the aircrafts and recent camera calibrations certificates;
- The Software for the Aerial Triangulation, Digital Terrain Model and Digital Ortho-rectified Imagery should be of internationally recognized providers;
- The Bidder shall provide the documented evidence confirming the capability to replace deployed aircraft or equipment in the case of failure within not more than 3 weeks to ensure the completion of aerial photography in time;
- The Bidder shall demonstrate that it has established appropriate Quality Assurance and Quality Control System and provide the Company (QA/QC) Plan together with the Bid Proposal. The QA/QC Plan should be prepared in accordance with the requirements of the ISO 10005: 1995 Quality management - Guidelines for quality standard. The ISO Quality Certificates provided will be considered as an advantage;
- The documented evidence confirming the compliance with the requirements above should be presented in the Bid Proposal. The failure to comply with this requirements will lead to the disqualification of the Bidder from this bid.

7.2 CONSULTANT'S STAFF

7.2.1. BIDDER PERSONNEL REQUIREMENTS

The Bidder shall assign highly qualified personnel in adequate numbers to complete the project in time. The number of the technical personnel required for data processing and production of the deliverables as per requirements of the project works is the responsibility of the Bidder but it must ensure and that the Project will be completed according to the Estimated Project Schedule agreed upon in the contract.

In addition to the technical personnel that will carry out the works the Bidder shall provide a full time Project Manager that should be permanently available on needs basis during the project time, for the project management, organisation and control of the project results and deliverables.

The Bidder shall also provide a part time Training Expert that will be the requirements for project management, key experts and personnel:

- Project Manager should have a Master's degree (or equivalent) in photogrammetry, Geomatics or related fields and a minimum of 10 years of experience of similar projects management including a minimum of 5 years in Africa or developing countries in equatorial conditions; good management and reporting skills; language proficiency - must be fluent in English/French;
- Specialized Technicians/ Key staff - should have a minimum of 5 years of experience in data capture, processing and production of data outputs like databases, charts and maps as well as necessary professional licenses. Experience for similar projects in similar environments and airports in Africa, practical experience of similar projects from east Africa will be an advantage; language proficiency - must be fluent in English/French;

- QA/QC Expert - should have masters or equivalent degree in Photogrammetry or similar disciplines, good practical and theoretical experience in the relevant fields and a minimum of 5 years of practical work and project management with similar assignments; good analytic skills and quality management practices providing the necessary check through policies and procedures; language proficiency - must be fluent in English (respectively in French for francophone states).

Requirements of technical personnel that will carry out data processing and production of required products and deliverables:

i) Degree/Diploma in relevant fields such as aerial photography, photogrammetry, spatial data management etc.;

ii) A minimum of 3 years of practical experience in the production of similar products for similar terrain conditions.

7.3 SUBMISSION OF CURRICULUM VITAE

Detailed Curriculum vitae of all relevant technical and administrative staff involved shall be submitted in the bidder's proposal

8. REPORTS

The Service Provider will provide detailed **monthly progress reports** (including the inception report, and final report) on the status of the project, which will include, at the appropriate stages of the project:

(a). One Draft digital copy of each aerodrome's map AutoCAD 2010 (aerodromes), compatible with other software such as Arc Info and ArcView GIS. This will be checked by the client for accuracy and to ascertain that no features which were left out.

(b). One final digital map of each aerodrome [list of aerodrome] in AutoCAD

(c). Aerial photos of the aerodromes covering the total area to be digitized at an appropriate scale as will be proposed by the service provider and accepted by the client;

(d). A set of hard copies of the digitized maps ie 10 copies of A_o sealed in plastic and 05 copies of A_1, sealed in plastic;

(e). Raw survey data files in excel format;

(f). Traverse and levelling computations;

(g). Tabulated obstacle data for areas 1, 2, 3 and 4 in AIXM 5.1/AIXM5.2 and Excel format (see appendix 1)

(h). Project reports (monumentation report, data capture report including the methodology and photographs, image development report, sensitization report and WGS-84 survey report). These will be appended to the main final report.

9. MEETINGS WITH [ORGANISATION] STAFF

There shall be three meetings at the clients' premises in **[location]:**

(a). The first one will be at the inception of the project;

(b). The second one will be at the time of presentation of the drafts by the consultant;

(c). The last meeting will take place at the handover of satisfactorily complete documents by the consultant to the client.

The Service provider shall formerly present the inception report and final report to the Client in a meeting at the Client's premises in **[location].**

10. TIME SCHEDULE

10.1. COMMENCEMENT

The Consultant will commence work within the timeframe that will be specified in the Contract.

10.2 ASSIGNMENT PERIOD

This assignment is planned to last 16 months allocated as follows: (each 4months)

(a). Physical inspection and survey of the scoped area - 3 month;

(b). Production of a draft digital plan - 5 month;

(c). Production of the final digital map, hardcopies, and other deliverables - 4 month.

10.3. PROJECT DELAYS

Measures are to be put in place by both **[organisation]** and the successful contractor to as realistically as possible avoid and where found to be inevitable mitigate any delays that may arise during the execution of the project.

11. RISK PLAN

The consultant shall submit a risk register indicating clearly all the anticipated risks and proposed mitigation measures to address such risks.

12. FINANCIAL PROPOSAL

(a). The financial proposal shall list all costs associated with the assignment broadly categorised as follows:

i. Fees (remuneration);

ii. Project execution costs;

iii. Reimbursables.

(b). The total proposal price shall be broken down into the following cost components using the appropriate forms:

i. Summary of Proposal Price (Breakdown of Lump Sum);

ii. Breakdown of Fees (remuneration);

iii. Breakdown of Project execution costs for the various project activities including; Community sensitization, Ground surveying, 3D Line mapping, Obstacle data mapping, TOD airspaces mapping, Ground Truthing, Map Compilation and Printing for all aerodromes within the area of coverage, Data loading, hands on Training on data usage, integration and interpretation, among other activities;

iv. Breakdown of Reimbursable expenditure, for staff (foreign and national in the field and at headquarters), such as transportation (international and local), communication, printing etc.;

(c). The total proposal price shall be broken down into the separate activities indicated in the Statement of Requirements with the cost elements expressed for each activity;

(d). The total proposal price shall be subjected to a withholding tax of 15%;

(e). The completed financial proposal forms will be used to compile the Breakdown of Contract Price in any resulting Agreement as adjusted if necessary during evaluation or negotiation. The Breakdown of Contract Price will determine prices for any additional Services or costs;

(f). A form has been attached for use to prepare the financial proposal; and

(g). All proposal prices shall be in Uganda Shillings.

13. DATA AND INFORMATION TO BE PROVIDED BY THE POE

The Client will provide the following information:

a. Physical location of the scoped areas;

b. Existing digital map;

c. Existing Aerial photos.

14. ASSIGNMENT MANAGEMENT AND ADMINISTRATION

The Client will coordinate and manage this task through/ under the auspices of the Projects Manager nominated by **[organisation]** who will coordinate the Consultant's activities as well as issuing the necessary approvals to the Consultant on behalf of the Client.

If the nominated Projects Manager does not justify enough experience on WGS-84 and geospatial constraints, technical project Manager should be nominated along with the Projects Manager.

15. REFERENCES

The consultant shall make reference to the latest relevant documentation including but not limited to:

- ICAO Annex 4: Aeronautical Charts;
- ICAO Annex 14 - Aerodromes, Volume l: Aerodrome Design and Operations;
- ICAO Annex 15: Aeronautical Information Services;
- ICAO Document 8697 -Aeronautical Chart Manual;
- ICAO Document 9881 - Guidelines for Electronic Terrain, Obstacle and Aerodrome Mapping Information;
- ICAO Document 9674 - World Geodetic System 1984 (WGS-84) Manual v11. Standards related to electronic terrain and obstacle data collection;
- ISO 8601 - Data elements and interchange formats -- Information interchange -- Representation of dates and times;
- ISO 19109 - Geographic information -- Ru les for application schema Body Title Edition;
- ISO 19110-Geographic information -- Methodology for feature cataloguing;
- ISO 19113 - Geographic information -- Quality principles;
- ISO 19114 - Geographic information -- Quality evaluation procedures;
- ISO 191 15 – Metadata;
- ISO 19117 - Geographic information =Portrayal;
- ISO 19123 - Geographic information -- Schema for coverage geometry and Functions xvi. ISO 19131 - Geographic information -- Data product specifications;
- Manual on specific requirements for AMDBs and TOD;
- ICAO Annex 10 Vol. 1 and 4: Aeronautical Telecommunications;
- ICAO Doc 9981 PANS Aerodromes;
- ICAO Doc 8168 Vol. 2: PANS Aircraft Operations;
- ICAO Doc 9137: Aerodrome Services Manual Part 6: Obstacles;
- European Aviation Safety Agency (EASA) - Easy Access Rules for Aerodromes (Regulation (EU) No 139/2014) (January 2018);
- ICAO Doc 10066 PANS AIM; and
- Control of Obstacles guidance.

16. APPENDICES

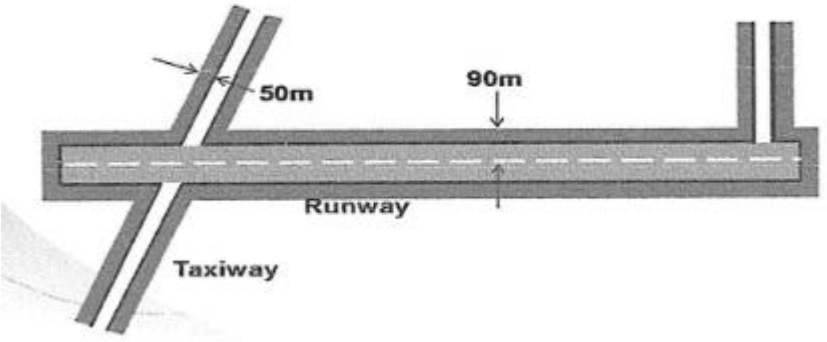
16.1 APPENDIX 1: SAMPLE OBSTACLE DATA TABLES

See Excel file.

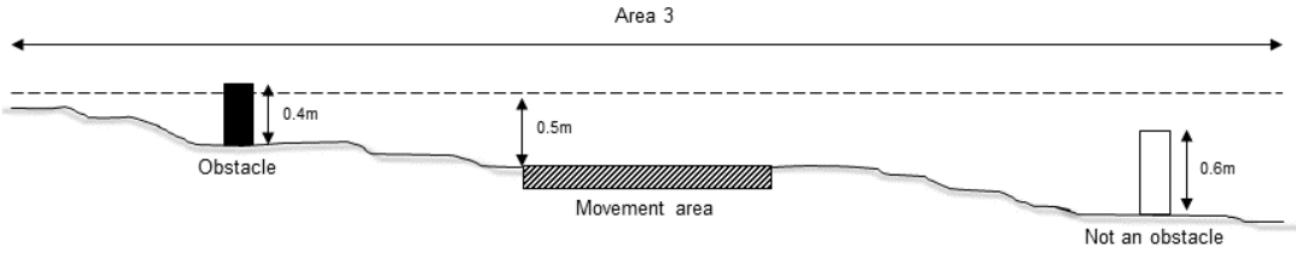
16.2 APPENDIX 2: SPECIFICATIONS FOR TOD AREAS 3 AND 2

16.2.1. AREA 3

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

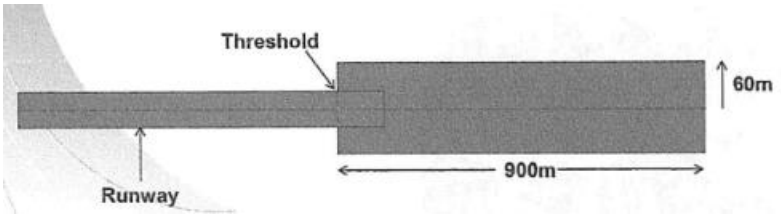


- Obstacles are 0.5 m above



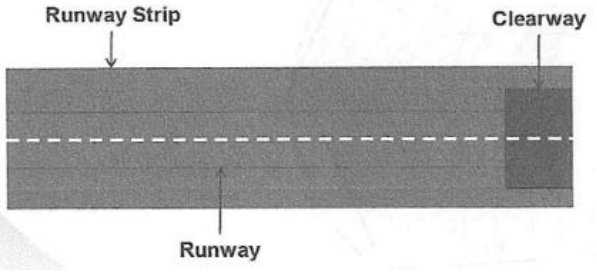
16.2.2 AREA 4

The area extending 900 m prior to the runway threshold and 60 m each side of the extended runway centre line in the direction of the approach on a precision approach runway, Category II or III.

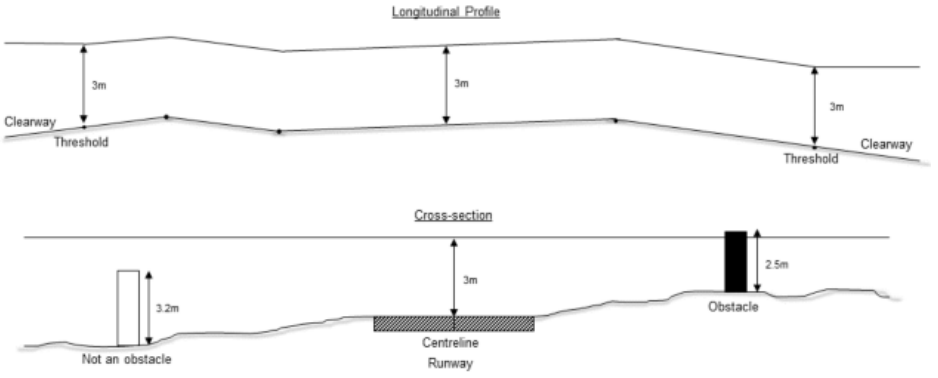


16.2.3 AREA 2a

- A rectangular area around a runway that comprises the runway strip plus any clearway that exists.

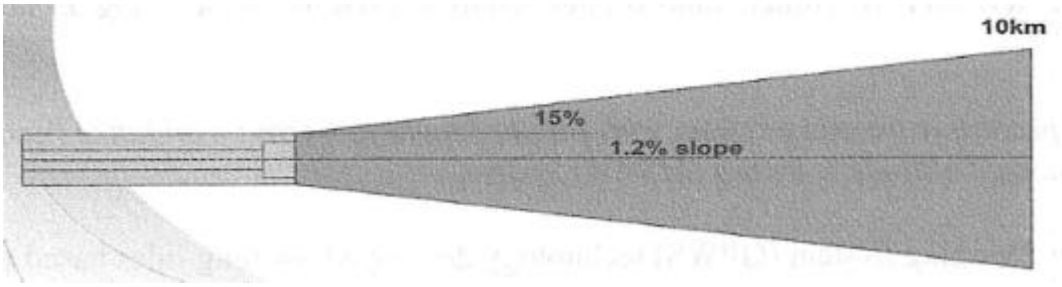


- The Area 2a obstacle collection surface shall have height of 3 m above the nearest runway elevation measured along the runway centre line, and for those portions related to a clearway, if one exists, at the elevation of the nearest runway end;



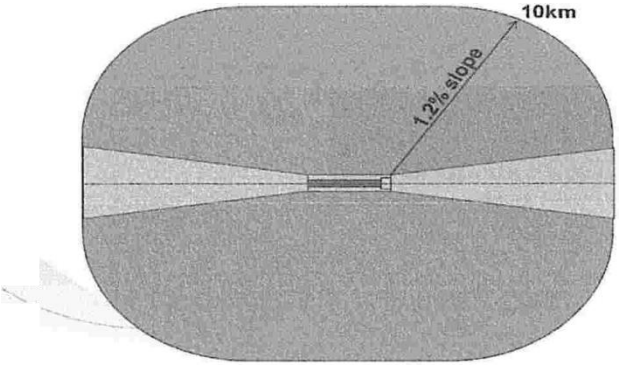
16.2.4 AREA 2b

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



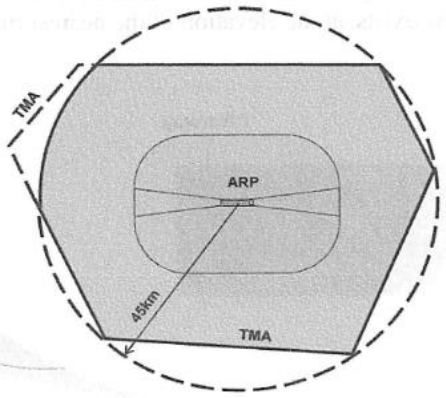
16.2.5 AREA 2c

- An area extending outside Area 2a and Area 2b at a distance of not more than 10 km from the boundary of Area 2a;
- The Area 2c collection surface has a 1.2% slope extending outside Area 2a and Area 2b at a distance of not more than 10 km from the boundary of Area 2a.
- The initial elevation of Area 2c shall be the elevation of the point of Area 2a at which it commences;



16.2.6 AREA 2d

- An area outside the Areas 2a, 2b and 2c up to a distance of 45 km from the aerodrome reference point, or to an existing TMA boundary, whichever is nearest
- The Area 2d obstacle collection surface has a height of 100 m above ground.



16.3. APPENDIX 3: OBSTACLE DATA SETS

(1) Obstacle data sets shall contain the digital representation of the vertical and horizontal extent of obstacles.

(2) Obstacle data shall not be included in terrain data sets.

(3) Obstacle data shall be provided for obstacles in Area 1 whose height is 100 m or higher above ground.

(4) 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.

(5) For aerodromes regularly used by international civil aviation, obstacle data shall be provided for:

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

(b). 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; and

(c). penetrations of the aerodrome obstacle limitation surfaces.

Note.— Take-off flight path areas are specified in Annex 4, 3.8.2. Aerodrome obstacle limitation surfaces are specified in Annex 14, Volume 1, Chapter 4.

(6) For aerodromes regularly used by international civil aviation, obstacle data should be provided for Areas 2b, 2c and 2d for obstacles that penetrate the relevant obstacle data collection surface specified as follows:

a. 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 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;

b. Area 2c: an area extending outside Area 2a and Area 2b at a distance of not more than 10 km from the boundary of Area 2a. The Area 2c 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; and

c. Area 2d: 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; except that data need not be collected for obstacles less than a height of 3 m above ground in Area 2b and less than a height of 15 m above ground in Area 2c.

(7) For aerodromes regularly used by international civil aviation, obstacle data should be provided 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.

(8) 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.

(9) Where additional obstacle data is collected to meet other aeronautical requirements, the obstacle data sets should be expanded to include this additional data.

(10) At aerodromes regularly used by international civil aviation, electronic obstacle data shall be provided for all obstacles within Area 2 that are assessed as being a hazard to air navigation.

16.4. APPENDIX 4: BASIC O B S T A C L E S CONCEPTS

16.4.1. OBSTACLES

Existing applications of the term "obstacle" go some way to identify the problem of providing a single, all inclusive, definition:

16.4.1.1. ICAO ANNEX 15 CHAPTER 2 DEFINITION OF AN OBSTACLE

"All fixed (whether temporary or permanent) and 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."

This definition is based around the need to protect aircraft and air navigation, i.e. an obstacle is an object which can potentially affect aircraft operations.

16.4.1.2. ICAO DOC 8168 PANS-OPS

ICAO Doc 8168 does not provide a definition of what constitutes an obstacle, rather it defines a series of surfaces that either must not be penetrated or anything which does penetrate them constitutes an obstacle and adequate clearance of it must be provided.

16.4.1.3. OBSTACLE MANAGEMENT

Obstacle management is about confirming that structures do not impact aircraft operations. This is achieved by establishing processes to ensure that obstacles either have not penetrated the defined surface, are not constructed in the first place or that their demolition is known.

As may be seen from these three points of view, there is no single definition of what an obstacle is, with it differing depending upon the perspective of the user and application.

It has, therefore, been necessary to define what is meant by "obstacle" in the context of bath this manual and a wider Aeronautical Information Management (AIM) context. The following definition has been derived:

"All fixed (whether temporary or permanent) and mobile objects, or parts thereof, that penetrate the identified obstacle assessment surfaces or whose height above ground level exceeds a defined minima."

Data models for obstacles must correctly reflect the position, shape and temporality of an obstacle as well as providing sufficient information about the obstacle, such as its type, markings and lighting.

A basic obstacle model would allow for a simple shape to be defined, with more complex approaches allowing a number of "parts" to be described. This latter approach is desirable where obstacles are made up of distinct parts which together form a whole. An example would be a building which was basically rectangular in shape but has an aerial on the roof which extends the height. Whilst an overall "bounding" box could be described, this may adversely impact operations, as it restricts the use of a larger area than that actually occupied by the building. A compound shape comprising these two elements would more closely reflect reality.

Whilst terrain is predominantly static, obstacles are relatively dynamic, with temporary obstacles such as cranes being very commonplace. It is, therefore, essential that the ability to define the temporality and status of an obstacle is provided for. The latter is needed as obstacles are typically planned, under construction, existing, planned for removal, being removed and removed. In some cases, flight operations are adjusted based on the status of the obstacle.

16.4.1.4. OBSTACLE DATA SET — CONTENT, NUMERICAL SPECIFICATION AND STRUCTURE

i) Obstacle data shall comprise the digital representation of the vertical and horizontal extent of the obstacle. Obstacles shall not be included in terrain data sets. Obstacle data elements are features that shall be represented in the data sets by points, lines or polygons

ii) 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 PANS-AIM Appendix 6, Table A6-2.

Note.- By definition, obstacles can be fixed (permanent or temporary) or mobile. Specific attributes associated with mobile (feature operations) and temporary types of obstacles are annotated in Appendix 6, Table A6-2, as optional attributes. If these types of obstacles are to be provided in the data set, appropriate attributes describing such obstacles are also required.

16.5. APPENDIX 5: OBSTACLE DATA MODELLING

16.5.4. OBSTACLE DATA PRODUCT SPECIFICATIONS

i) To allow and support the interchange and use of sets of electronic obstacle data among different data providers and data users, the ISO 19100 series of standards for geographic information shall be used as a general data modelling framework.

ii) A comprehensive statement of available electronic obstacle data sets shall be provided in the form of terrain data product specifications as well as obstacle 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).

Note. - ISO Standard 19131 specifies the requirements and outline of data product specifications for geographic information.

iii) The overview of obstacle data product specification shall provide an informal description of the product and shall contain general information about the data product.

iv) Content information of feature-based obstacle data sets shall each be described in terms of an application schema and a feature catalogue. Application schema shall provide a formal description of the data structure and content of data sets while the feature catalogue shall provide the semantics of all feature types together with their attributes and attribute value domains, association types between feature types and feature operations, inheritance relations and constraints. Coverage is considered a subtype of a feature and can be derived from a collection of features that have common attributes. Both obstacle data product specifications shall identify clearly the coverage and/or imagery they include and shall provide a narrative description of each of them.

Note 1.-ISO Standard 19109 contains rules for application schema white ISO Standard 19110 describes feature cataloguing methodology for geographic information.

Note 2.-ISO Standard 19123 contains schema for coverage geometry and functions.

v) obstacle data product specifications shall include information that identifies the reference system used in the data product. This shall include the spatial reference system and temporal reference system. Additionally, obstacle data product specifications shall identify the data quality requirements for each data product. **This shall include a statement on acceptable conformance quality levels and corresponding data quality measures**. This statement shall cover all the data quality elements and data quality sub-elements, even if only to state that a specific data quality element or sub-element is not applicable.

Note.-ISO Standard 19113 contains quality principles for geographic information white ISO Standard 19114 covers quality evaluation procedures.

vi) The principles and criteria applied in the maintenance of obstacle data sets shall also be provided with the data specifications, including the frequency with which data products are updated. Of particular importance shall be the maintenance information of obstacle data sets

and an indication of the principles, methods and criteria applied for obstacle data maintenance

Note. - ISO Standard 19117 contains a definition of the schema describing the portrayal of geographic information including the methodology for describing symbols and mapping of the schema to an application schema.

vii) The core obstacle metadata elements shall be included in the data product specifications. Any additional metadata items required to be supplied shall be stated in each product specification together with the format and encoding of the metadata.

Note.-ISO Standard 19115 specifies requirements for geographic information metadata.

viii) The obstacle data product specification, supported by geographical coordinates for each aerodrome included within the dataset, shall describe the following areas:

- Areas 2a, 2b, 2c, 2d;
- the take-off flight path area; and
- the obstacle limitation surfaces.

16.5.6. OBSTACLE DATA REQUIREMENTS

Obstacle data quality requirements are presented in Table 5 below.

Table 5: Obstacle data quality requirements

Subject	Property	Type	Description	Accuracy	Integrity	Origin Type	Pub. Resolution.	Chart Resolution.
Obstacle	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	Obstacles in Area 1	50 m	routine	surveyed	1 sec	as plotted
			Obstacles in Area 2 (including 2a, 2b, 2c, 2d, take-	5 m	essential	surveyed	1/10 sec	1/10 sec

			off flight path area and obstacle limitation surfaces)					
			Obstacles in Area 3	0.5 m	essential	surveyed	1/10 sec	1/10 sec
			Obstacles in Area 4	2.5 m	essential	surveyed		
	Horizontal extent	Distance	Horizontal extent of the obstacle					
	Elevation	Elevation	Obstacles in Area 1	30 m	routine	surveyed	1 m or 1 ft	3 m (10 ft)
	Height	Height	Obstacles in Area 2 (including 2a, 2b, 2c, 2d, take-off flight path area and obstacle limitation surfaces)	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 ft	1m or 1 ft
			Obstacles in Area 4	1 m	essential	surveyed	0.1 m	
	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					

Table 6: Obstacle attribute

Table 6 presents the list of attributes defined to describe obstacle data. Attributes that are designated "mandatory" must be recorded. It is recommended that "optional" attributes be recorded as well.

N°	Obstacle attribute	Mandatory/Optional
1	Area of coverage	Mandatory
2	Data source identifier	Mandatory
3	Obstacle identifier	Mandatory
4	Horizontal accuracy	Mandatory
5	Horizontal confidence level	Mandatory
6	Horizontal position	Mandatory
7	Horizontal resolution	Mandatory
8	Horizontal extent	Mandatory
9	Horizontal reference system	Mandatory
10	Elevation	Mandatory
11	Height	Mandatory
12	Vertical accuracy	Mandatory
13	Vertical confidence level	Mandatory
14	Vertical resolution	Mandatory
15	Vertical reference system	Mandatory
16	Obstacle type	Mandatory
17	Geometry type	Mandatory
18	Integrity	Mandatory
19	Date and time stamp	Mandatory
20	Unit of measurement used	Mandatory
21	Operations	Optional
22	Effectivity	Optional
23	Lighting	Mandatory
24	Marking	Mandatory

16.5.7. HORIZONTAL REFERENCE SYSTEM

i) World Geodetic System- 1984 (WGS-84) shall be used as the horizontal (geodetic) reference system for international air navigation. Consequently, published aeronautical geographical coordinates (indicating latitude and longitude) shall be expressed in terms of the WGS-84 geodetic reference datum.

Note 1.-Comprehensive guidance material concerning WGS-84 is contained in the World Geodetic System-1984 (WGS-84) Manual (Doc 9674)

Note 2. - Specifications governing the determination and reporting (accuracy of field work and data integrity) of WGS-84-related aeronautical coordinates for geographical positions established by aeronautical data catalogue of PANS-AIM.

ii) In precise geodetic applications and some air navigation applications, temporal changes in the tectonic plate motion and tidal effects on the Earth's crust should be modelled and estimated To reflect the temporal effect, an epoch should be included with any set of absolute station coordinates

Note 1.- The epoch of the WGS-84 (G873) reference frame is 1997.0 white the epoch of the latest updated WGS-84 (Gll50) reference frame, which includes plate motion model, is 2001.0. (G indicates that the coordinates were obtained through Global Positioning System (GPS) techniques, and the number following G indicates the GPS week when these coordinates were implemented in the United States of America's National Geospatial-Intelligence Agency 's (NGA 's) precise ephemeris estimation process.).

Note 2.- The set of geodetic coordinates of globally distributed permanent GPS tracking stations for the most recent realization of the WGS-84 reference frame (WGS-8 4 (G 1150)) is provided in Doc 9674. For each permanent GPS tracking station, the accuracy of an individually estimated position in WGS-84 (G1150) has been in the order of 1 cm (lσ).

Note 3.-Another precise worldwide terrestrial coordinate system is the International Earth Rotation Service (IERS) Terrestrial Reference System (ITRS), and the realization of ITRS is the IERS Terrestrial Reference Frame (ITRF). Guidance material regarding the ITRS is provided in Appendix C of Doc 9674. The most current realization of the WGS-84 (G1150) is referenced to the ITRF 2000 epoch. The WGS-84(G1150) is consistent with the ITRF 2000 and in practical realization the difference between these two systems is in the one to two centimeter range worldwide, meaning WGS-84 (G1150) and ITRF 2000 are essentially identical.

iii) Geographical coordinates which have been transformed into WGS-84 coordinates but whose accuracy of original field work does not meet the applicable requirements shall be identified by an asterisk.

iv) The order of publication resolution of geographical coordinates shall be that specified while the order of chart resolution of geographical coordinates shall be that specified in PANS-AIM Appendix 1, Table A1-6 and A1-8.

16.5.8. VERTICAL REFERENCE SYSTEM

i) Mean sea level (MSL) datum, which gives the relationship of gravity-related height (elevation) to a surface known as the geoid, shall be used as the vertical reference system for international air navigation.

Note 1.-The geoid globally most close/y approximates MSL. It is defined as the equipotential surface in the gravity field of the Earth which coincides with the undisturbed MSL extended continuously through the continents.

Note 2.- Gravity-related heights (elevations) are also referred to as orthometric heights white distances of points above the ellipsoid are referred to as ellipsoidal heights.

ii) The Earth Gravitational Model - 1996 (EGM-96), containing long wavelength gravity field data to degree and order 360, shall be used by international air navigation as the global gravity model.

Note.- Guidance material concerning EGM-96 is contained in Doc 9674

iii) At those geographical positions where the accuracy of EGM-96 does not meet the accuracy requirements for elevation and geoid undulation specified in Annex 15, on the basis of EGM-96 data, regional, national or local geoid models containing high resolution (short wavelength) gravity field data shall be developed and used. When a geoid model other than the EGM-96 model is used, a description of the model used, including the parameters required for height transformation between the model and EGM-96, shall be provided in the Aeronautical Information Publication (AIP).

Note. -Specifications governing determination and reporting (accuracy of field work and data integrity) of elevation and geoid undulation at specific positions at aerodromes/heliports are given in PANS-AIM appendix 1, Table A1-1.

iv) In addition to elevation referenced to the MSL (geoid), for the specific surveyed ground positions, geoid undulation (referenced to the WGS-84 ellipsoid) for those positions specified in Appendix 1 shall also be published.

v) The order of publication resolution of elevation and geoid undulation shall be that specified in PANS-AIM, Appendix 1 and Table A1-1.

16.5.9. TEMPORAL REFERENCE SYSTEM

i) For international civil aviation, the Gregorian calendar and Coordinated Universal Time (UTC) shall be used as the temporal reference system.

Note 1. -A value in the time domain is a temporal position measured relative to a temporal reference system.

Note 2.-Coordinated Universal Time (UTC) is a time scale maintained by the Bureau International de l'Heure and the IERS and forms the basis of a coordinated dissemination of standard frequencies and lime signals.

Note 3.-See Attachment D of Annex 5 for guidance material relating to UTC.

Note 4.-ISO Standard 8601 specifies the use of the Gregorian calendar and 24-hour local or UTC for information interchange while ISO Standard 19108 prescribes the Gregorian calendar and UTC as the primary temporal reference system for use with geographic information.

ii) When a different temporal reference system is used for some applications, the feature catalogue, or the metadata associated with an application schema or a data set, as appropriate, shall include either a description of that system or a citation for a document that describes that temporal reference system.

Note.-1SO Standard 19108, Annex D, describes some aspects of calendars that may have to be considered in such a description.

16.5.10. METADATA

i) Metadata shall be collected for aeronautical data processes and exchange points. This metadata collection shall be applied throughout the aeronautical information data chain, from survey/origin to distribution to the next intended user.

ii) The metadata to be collected 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..

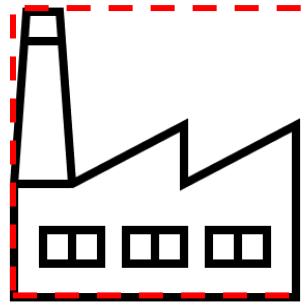
Note.- The function performed indicates any action of originating, transmitting or manipulating the data.

16.6. OBSTACLES DATA CAPTURE REQUIREMENTS

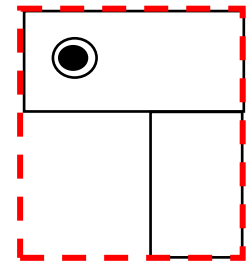
Feature capture rules are listed:

16.6.1. HORIZONTAL CAPTURE RULE

- Accuracy: **Area 1 = 50 meters,**
  Area 2 = 5 meters
  Area 3 = 0.5 meter
  Area 4 = 2.5 meters
  (Annex 15 requirement)
- Resolution: **Area 1 = 1 sec,**
  Area 2 &3 = 0.1 sec
  (0.01 and 0.001 are respectively required at Data Originator level for rounding purpose)
- Threshold value for point collection:
  - a value of two times horizontal accuracy will be applied as a criterion to require a geometry different from **point**.
  - In **area 2** horizontal accuracy is 5 meters. Threshold value would be a maximum of **10 meters**.
  - In **area 3**: **1 meter**.
- Geometry
  - Below this width, obstacle will be a **point**, example a tree.
  - If an obstacle has a width more than 10 meters in area 2 and 1 meter in area 3, it would be **line**. An edge of trees could be a line too.
  - An obstacle of more than 10 x 10 m in area 2 and 1x1 m in area 3 should be a **polygon.** Example: building of 40 floors…
  - See below for more complex cases.
- Obstacle bounding box: in case of irregular shape obstacles conservative measure should have to be taken into account to never let an obstacle part undermeasured.



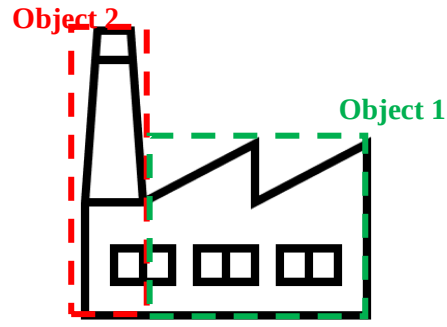
Side view



top view

16.6.2. VERTICAL CAPTURE RULE

- Accuracy: **Area 1 = 30 meters,**
  Area 2 = 3 meters
  Area 3 = 0.5 meter
  Area 4 = 1 meter
  (Annex 15 requirement)
- Resolution: **Area 1&2 = 1 meter,**
  Area 3&4 = 0.1 meter
  (0.01 and 0.001 are respectively required at Data Originator level for rounding purpose)
- Complex case: most of the time an obstacle will be its four corners for horizontal extension and its apex for vertical elevation, but for some seldom case it should be interesting to segment complex obstacle. Typically, a Factory with a big chimney in order to avoid bad operational side effect. The rule should be: application of Threshold to face that case.



Side view

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).

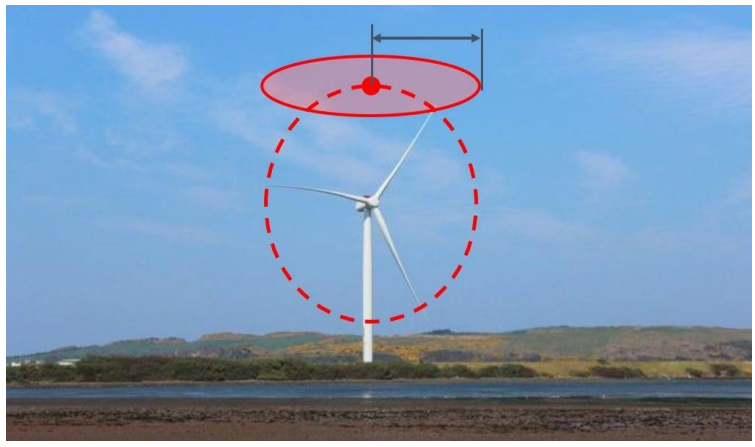


Figure A1: Capture of the relevant elevation and extent of a wind turbine

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.

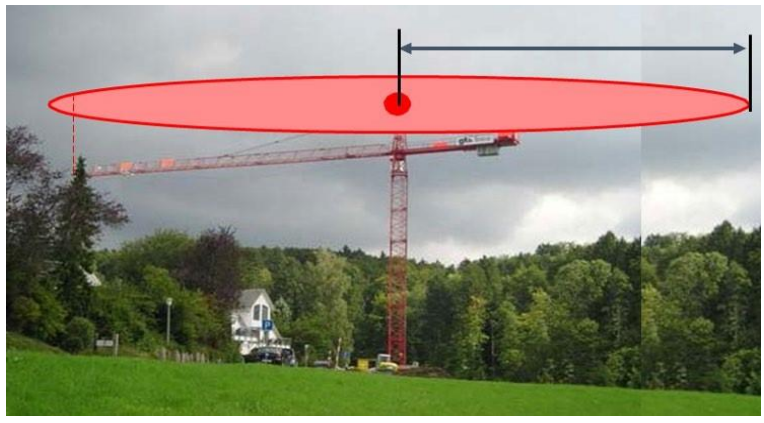


Figure A2: Capture of the relevant elevation and extent of a crane

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.

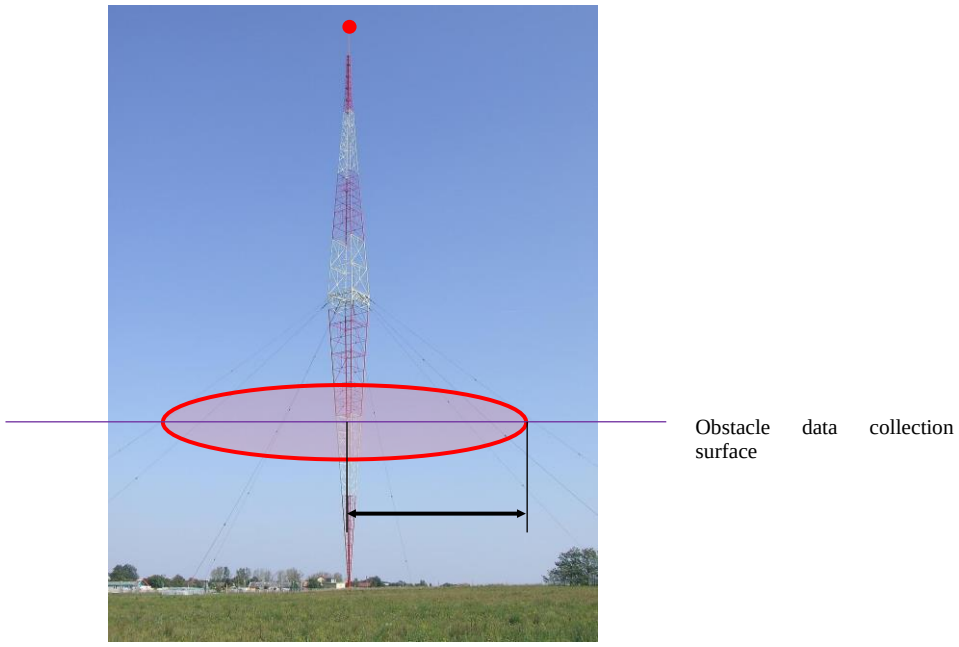


Figure A3: Capture of the relevant elevation and extent of a mast with guy wires

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.

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.

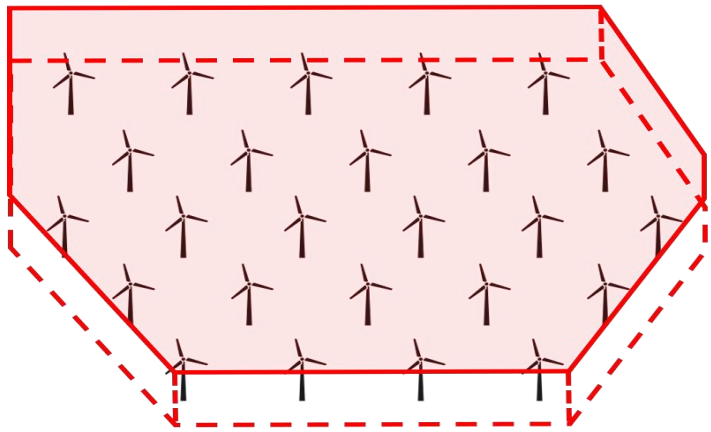


Figure A4: Capture of a wind farm as a polygon

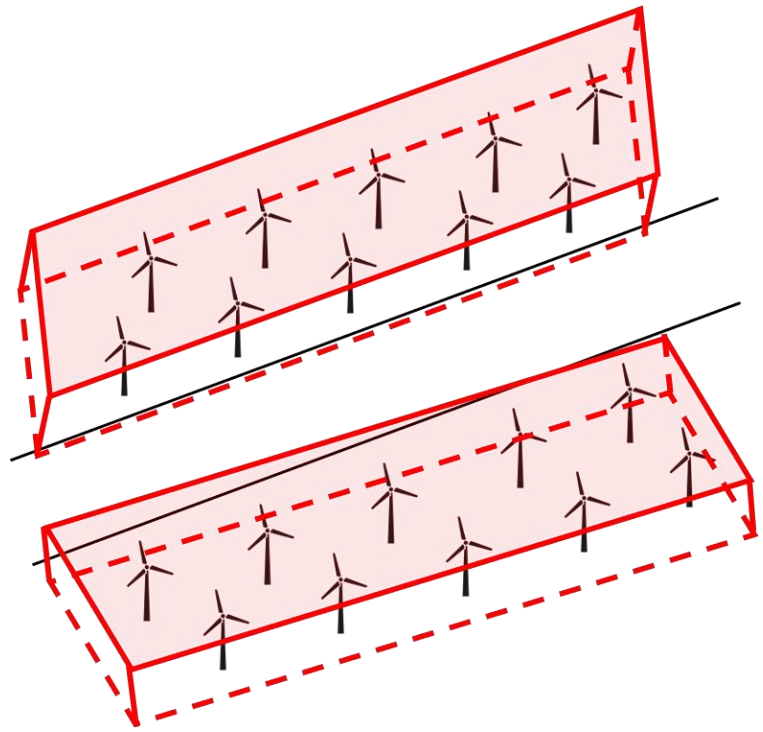


Figure A5: Capture of wind park with space for potential helicopter operations

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

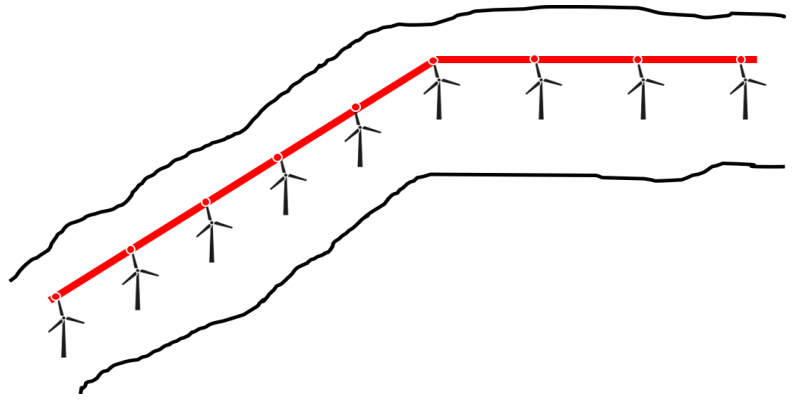


Figure A6: Capture of a wind farm as a line

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.

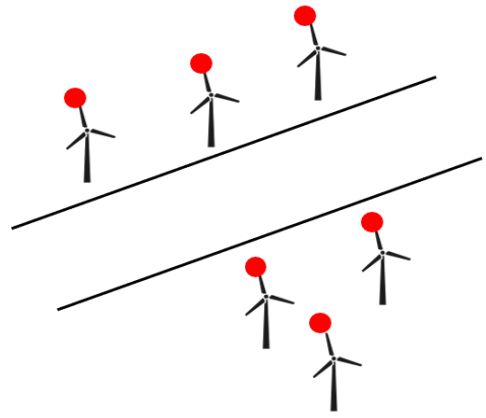


Figure A7: Capture of wind turbines as individual points

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

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

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}

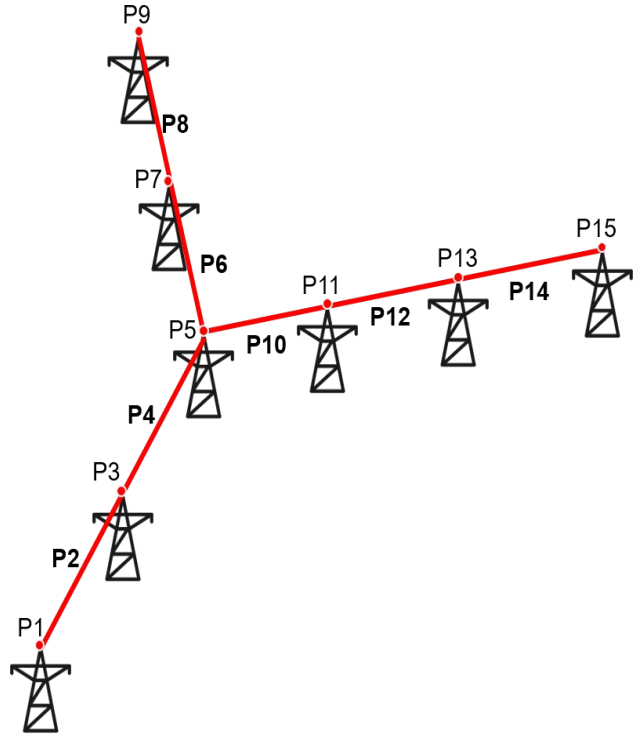


Figure A10: Capture of power line networks

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.

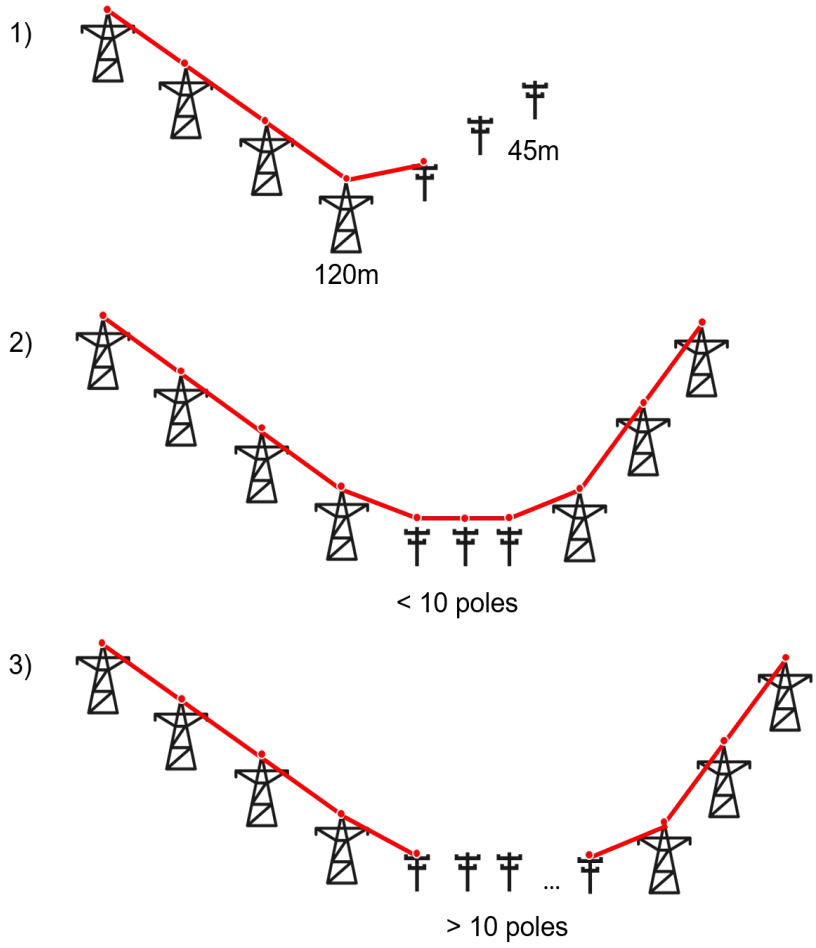


Figure A11: Capture of power lines with segments below the collection surface

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.

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

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.

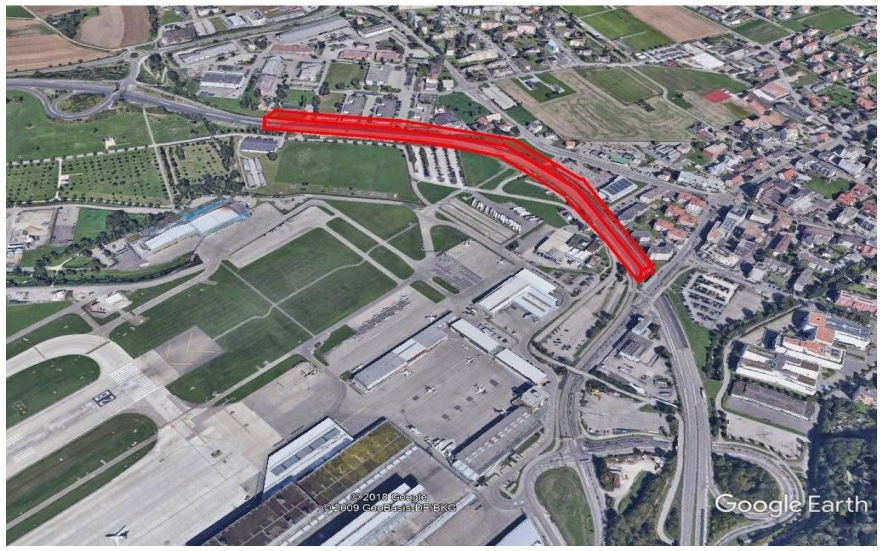


Figure A13: Trucks on a highway are mobile obstacles in the approach area of a runway

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.

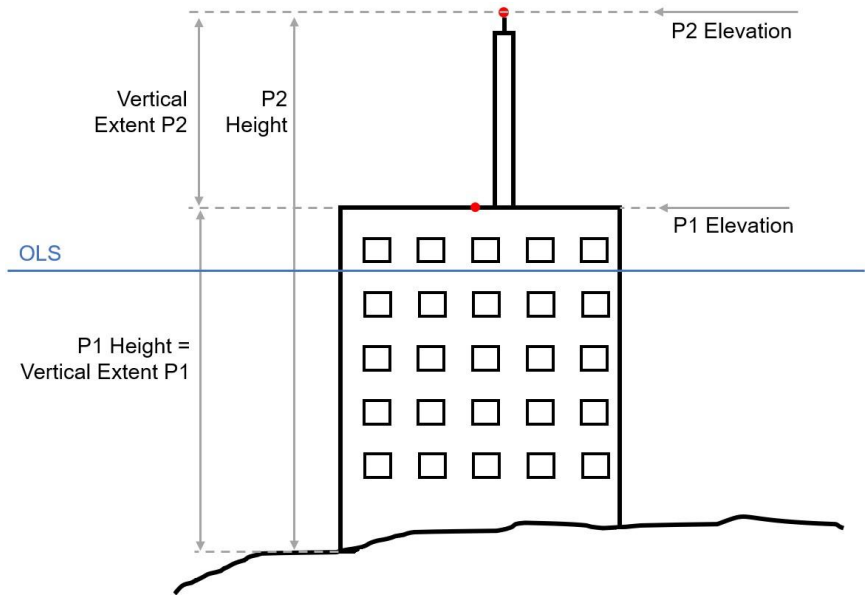


Figure A14: Example of a segmented obstacle

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.

VEGETATION

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.

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.

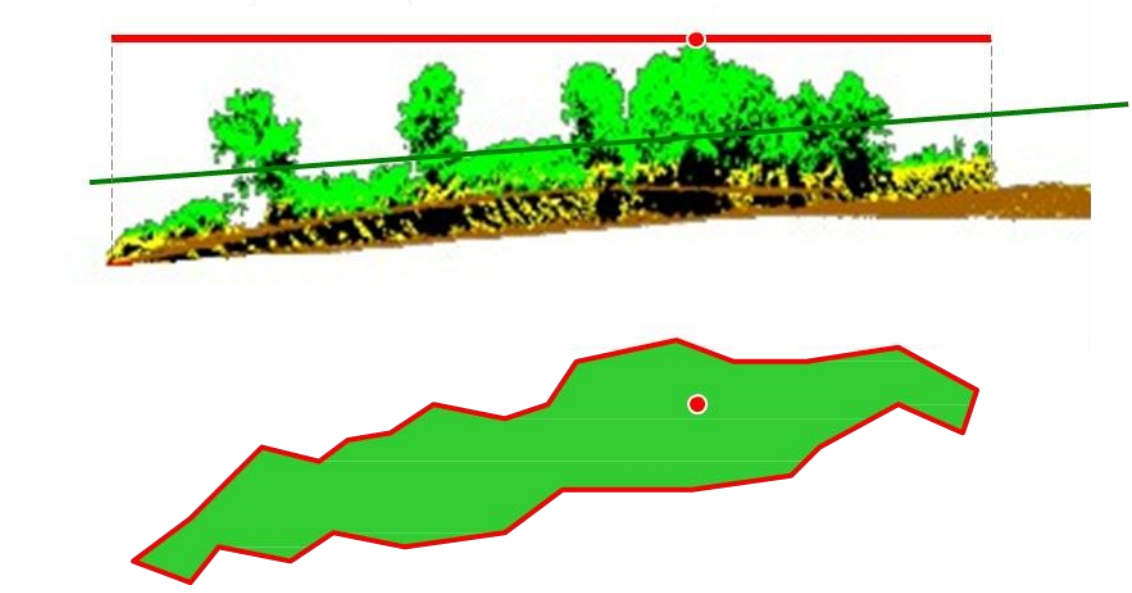


Figure A15: Capture of a forest as a polygon

Attribute capture rule

All mandatory Attributes (Annex 15 requirement), except Lighting and Marking, shall be captured and documented according to Appendixes A & B. Lighting, Marking and optional **Attributes** should be documented