



Doc 9881

Guidelines for Electronic Terrain, Obstacle and Aerodrome Mapping Information

Foreword

The introduction of provisions for electronic terrain data, for one common vertical datum for air navigation and the updating of existing specifications for obstacle data, stems from Recommendation 2.3/1 of the Aeronautical Information Services/Aeronautical Charts (AIS/MAP) Divisional Meeting (1998) for development of an amendment to Annex 4 — *Aeronautical Charts* on electronic terrain data.

On 29 October 1998, the Air Navigation Commission approved the inclusion of Task No. AIS-9802: Electronic terrain data, in the Technical Work Programme (TWP) of the Organization in the Air Navigation Field.

In light of instructions given by the Air Navigation Commission, a proposal for an amendment to Annex 4 concerning electronic terrain and obstacle data was subsequently developed by the Secretariat in consultation with the joint RTCA Special Committee 193 and the European Organization for Civil Aviation Electronics (EUROCAE) Working Group 44.

In accordance with ANC Task No. AIS-9802, amendments to Annex 4 were initially planned. However, one State, in their reply to a State letter soliciting comments concerning the proposed inclusion of electronic terrain data specifications in Annex 4, suggested that since “specifications relating to the provision of obstacles, cultural and vegetation data are already contained in Annex 15, the proposed material seemed more appropriately placed into Annex 15, particularly when considering that Annex 15, Appendix 7 already deals with “aeronautical data quality requirements”. It was also suggested that the proposed electronic terrain data quality requirements could easily be incorporated into Appendix 7 of Annex 15 — *Aeronautical Information Services*, while Annex 4 should continue to deal only with charting specifications, which are quite separate issues.

It was concluded that the proposed grouping together and placing of obstacle and aeronautical data with terrain data specifications into Annex 15 had merit. Additionally, it was envisioned that the conceptual modelling and interchange of both aeronautical and terrain data was to be based on a common modelling language, while to achieve networked interoperability of file transfer model, provisions aimed at an Extensible Mark-up Language (XML) should be implemented. For this reason, it was felt that placing both aeronautical and terrain data into one document would facilitate future amendments related to data interchange provisions. Finally, the proposed grouping was expected to improve understanding of the interrelationship and use of the two types of data which would, in turn, facilitate implementation of the relevant Standards and Recommended Practices (SARPs) by States.

On 23 February 2004, the Council of ICAO adopted Amendment 33 to Annex 15 which included, among other items, the addition of a new Chapter 10 — *Electronic Terrain and Obstacle Data*, a new Appendix 8 — *Terrain and Obstacle Data Requirements*, and a number of amendments to Appendix 1 — *Contents of Aeronautical Information Publication (AIP)* and Appendix 7 — *Aeronautical Data Quality Requirements*.

The purpose of this manual is to provide guidance for data gathering by data originators, for implementation by system designers and for use by the aviation community (e.g., aeronautical information and aeronautical charts services, air transport operators, air traffic services, aerodrome operators, approach and departure procedure designers).

This manual should be read in conjunction with the following related ICAO documents:

Annex 4 — *Aeronautical Charts*

Annex 6 — *Operation of Aircraft, Part I — International Commercial Air Transport — Aeroplanes*

Annex 11 — *Air Traffic Services*

Annex 14 — *Aerodromes, Volume I — Aerodrome Design and Operations, Volume II — Heliports*

Annex 15 — *Aeronautical Information Services*

Doc 8168 — *Procedures for Air Navigation Services — Operations (PANS-OPS)*

Doc 8126 — *Aeronautical Information Services Manual*

Doc 8697 — *Aeronautical Chart Manual*

Doc 9674 — *World Geodetic System — 1984 (WGS-84) Manual*

In providing the guidance material in this manual, the following non-ICAO documents were used:

EUROCAE ED-98A (RTCA DO-276A) — *User Requirements for Terrain and Obstacle Data*

EUROCAE ED-99A (RTCA DO-272A) — *User Requirements for Aerodrome Mapping Information*

EUROCAE ED-119 (RTCA DO-291) — *Interchange Standards for Terrain, Obstacle, and Aerodrome Mapping Data*

ISO 19103: Geographic information — Conceptual schema language

ISO 19107: Geographic information — Spatial schema

ISO 19108: Geographic information — Temporal schema

ISO 19109: Geographic information — Rules for application schema

ISO 19110: Geographic information — Feature catalogueing methodology

ISO 19111: Geographic information — Spatial referencing by coordinates

ISO 19112: Geographic information — Spatial referencing by geographic identifiers

ISO 19113: Geographic information — Quality principles

ISO 19114: Geographic information — Quality evaluation procedures

ISO 19115: Geographic information — Metadata

ISO 19118: Geographic information — Encoding

ISO/CD 19123: Geographic information — Schema for coverage geometry and functions (draft document dated February 2002)

ISO/CD 19131: Geographic information — Data product specification (draft document dated February 2, 2003)

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Users are invited to provide ICAO with suggestions for improvement or additions, based on their practical experience when using this manual. Errors or discrepancies noticed in the manual should be brought to the attention of:

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Table of Contents

Foreword	2
Table of Contents	5
Definitions	10
Acronyms	20
1 Document Overview	24
1.1 Electronic Terrain and Obstacle Data	24
1.2 Aerodrome Mapping Information	25
1.3 Application of this Manual	26
1.4 Data Exchange	28
1.4.1 Scope	28
1.4.2 Introduction	28
1.4.3 Data Set Transfer	29
1.4.4 Interchange Guidance	29
1.4.5 General Structure and Content of a Data Product Specification (DPS)	30
1.4.6 Reference systems	31
1.4.7 Terms, Definitions, and Assumptions	32
2 Terrain Data	33
2.1 Scope	33
2.1.1 Terrain Data Definition	33
2.1.2 Terrain Data Attributes	34
2.2 Terrain Data Quality Requirements	40
2.2.1 Introduction	40
2.2.2 Areas of Coverage	41
2.3 Data Product Specification	47
2.3.1 Overview	47
2.3.2 Specification Scopes	47
2.3.3 Data Product Identification	49
2.3.4 Data Content and Structure	51
2.3.5 Reference Systems	54
2.3.6 Data Quality	55
2.3.7 Data Capture	56
2.3.8 Data Maintenance	57
2.3.9 Portrayal	58

2.3.10	Data Product Delivery	59
2.3.11	Additional Information	60
2.3.12	Metadata	60
3	Scope	69
3.1	Scope	69
3.1.1	Obstacle Definition	69
3.1.2	Obstacle Data Attributes	69
3.2	Obstacle Data Quality Requirements	74
3.2.1	Introduction	74
3.2.2	Areas of Coverage	74
3.3	Data Product Specification	80
3.3.1	Overview	80
3.3.2	Specification Scopes	80
3.3.3	Data Product Identification	81
3.3.4	Data Content and Structure	83
3.3.5	Reference Systems	105
3.3.6	Data Quality	106
3.3.7	Data Capture	107
3.3.8	Data Maintenance	108
3.3.9	Portrayal	109
3.3.10	Data Product Delivery	109
3.3.11	Additional Information	111
3.3.12	Metadata	111
4	Aerodrome Mapping Data	119
4.1	Introduction	119
4.1.1	Purpose	119
4.1.2	Scope	119
4.1.3	Aerodrome Mapping Information	120
4.1.4	Aerodrome Mapping Data Considerations	121
4.2	Requirements	122
4.2.1	General Requirements	122
4.2.2	Specific Requirements for AMDBs	126
4.2.3	AMDB Quality	174
4.3	Aerodrome Mapping Data Product Specification	178
4.3.1	Overview	178

4.3.2	Specification Scopes	179
4.3.3	Data Product Identification	180
4.3.4	Data Content and Structure	182
4.3.5	Reference Systems	233
4.3.6	Data Quality	234
4.3.7	Data Capture	235
4.3.8	Data Maintenance	236
4.3.9	Portrayal	237
4.3.10	Data Product Delivery	237
4.3.11	Additional Information	239
4.3.12	Metadata	239
Appendix A: Applications		A-1
A.1	Terrain and Obstacle Data	A-1
A.1.1	Introduction	A-1
A.1.2	Background	A-1
A.1.3	Air Navigation Applications that use Terrain and Obstacle Data Sets	A-2
A.1.4	Ground Proximity Warning System (GPWS)	A-3
A.1.5	En-route “Drift-Down” Procedures	A-3
A.1.6	En-route Emergency Landing Location Selection	A-3
A.1.7	Synthetic vision	A-4
A.1.8	Minimum Safe Altitude Warning (MSAW) System	A-5
A.1.9	Instrument Procedure Design (including circling procedures)	A-6
A.1.10	Contingency Procedure Analysis and Determinations	A-6
A.1.11	Flight Simulators	A-7
A.2	Air Navigation Applications that use Aerodrome Mapping Data	A-7
A.2.1	Introduction	A-7
A.2.2	Navigation Applications that use Aerodrome Mapping Data	A-9
A.2.3	Charting Information	A-10
A.2.4	Surveillance and Conflict (Runway Incursion) Detection and Alerting	A-13
A.2.5	Route and Hold-Short Portrayal and Deviation Detection and Alerting	A-17
A.2.6	Portrayal of Digital ATIS Information	A-19
A.2.7	Aerodrome Surface Guidance and Navigation	A-20
A.2.8	Resource Management	A-22
A.2.9	Training and High Fidelity Simulation	A-23
A.2.10	Aerodrome Facility Management	A-24

A.2.11	Emergency and Security Services Management	A-26
A.2.12	Runway Operations	A-27
A.2.13	Notices to Airmen (NOTAM) and Aeronautical Data Overlays	A-29
A.2.14	Asset Management on the Aerodrome Surface Using Hand-held Computers	A-31
A.2.15	Synthetic Vision	A-32
Appendix B:	Remote Sensing Technologies	B-1
B.1	Summary	B-1
B.2	Sensor Types	B-1
B.3	Stereo Aerial Photography	B-1
B.4	Stereo Satellite Images	B-2
B.5	Interferometric Synthetic Aperture Radar (IFSAR)	B-2
B.6	Light Detection and Ranging	B-4
B.7	Digital Ortho-Rectified Imagery	B-4
Appendix C:	Data Quality	C-1
C.1	Quality Management	C-1
C.1.1	Introduction	C-1
C.1.2	Types of Errors	C-2
C.1.3	Error Assessment	C-3
C.1.4	Accuracy and Precision	C-5
C.1.5	Traceability	C-7
C.1.6	Quality Assurance	C-8
C.2	Quality Evaluation	C-8
C.2.1	Applying Quality Evaluation Procedures to Dynamic Data Sets	C-9
C.2.2	Reporting Data Quality	C-10
C.3	References	C-10
Appendix D:	Certification, Maintenance, and Temporal Considerations	D-1
D.1	Certification Guidelines	D-1
D.2	Terrain Database Generation Phases	D-1
D.2.1	Terrain Data Collection	D-1
D.2.2	Mathematical Transformations	D-2
D.2.3	Database Assembly	D-2
D.2.4	Verification	D-3
D.2.5	Validation	D-3
D.3	Obstacle Database Generation Phases	D-3
D.3.1	Obstacle Data Collection	D-4

D.3.2	Mathematical Transformations	D-4
D.3.3	Database Assembly	D-4
D.3.4	Verification	D-4
D.3.5	Validation	D-5
D.4	Maintenance of Databases	D-5
D.5	Data Set Maintenance and Update	D-5
D.5.1	Source Analysis and Evaluation Procedures	D-7
D.5.2	Clarification of Source Anomalies Procedures	D-7
D.5.3	Data Input Procedures	D-8
D.5.4	Data Validation Procedures	D-8
D.5.5	Data Verification Procedures	D-8
D.5.6	Update Mechanism	D-9
D.6	Temporal Considerations	D-9
D.6.1	Temporal Scales	D-9
D.6.2	Temporal Characteristics	D-10
D.6.3	Temporal Feature Relationships	D-10
D.6.4	Temporal Characteristics of Feature Relationships	D-11
D.6.5	Temporal Metadata Elements	D-12
D.6.6	Sample Conformance Criteria	D-12
Appendix E: Example of a Data Product Specification		E-1
Appendix F: Metadata Elements		F-1
Appendix G: Metadata Code Lists and Enumerations		G-1

Definitions

Accuracy. A degree of conformance between the estimated or measured value and the true value.

Note.— For measured positional data the accuracy is normally expressed in terms of a distance from a stated position within which there is a defined confidence of the true position falling

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.

Aerodrome elevation. The elevation of the highest point of the landing area.

Aerodrome mapping database (AMDB). One or more files containing information in a digital form that represent selected aerodrome features. This data includes geo-spatial data and metadata over a defined area. The files have a defined structure to permit an AMDB management system and other applications to make revisions that include additions, deletions, or modifications.

Aerodrome reference point (ARP). The designated geographical location of an aerodrome.

Aerodrome surface movement area. That part of an aerodrome that is to be used for the take-off, landing, and taxiing of aircraft. This includes runways, taxiways, and apron areas.

Aeronautical data. A representation of aeronautical facts, concepts or instructions in a formalized manner suitable for communication, interpretation or processing.

Aeronautical database. Any data that is stored electronically in a system that supports airborne or ground based aeronautical applications. An aeronautical database may be updated at regular intervals.

Aeronautical data preparation agency. An agency, public or private, other than an originator and/or publisher of government source documents, who compiles official government document information into charts or electronic formats for computer-based systems.

Aeronautical Information Publication (AIP). A publication issued by or with the authority of a State and containing aeronautical information of a lasting character essential to air navigation.

Aeronautical information regulation and control (AIRAC). A system aimed at advance notification based on common effective dates, of circumstances that necessitate significant changes in operating practices.

Aeronautical information service (AIS). A service established within the defined area of coverage responsible for the provision of aeronautical information/data necessary for the safety, regularity and efficiency of air navigation.

Aircraft stand. A designated area on an apron intended to be used for parking an aircraft.

Altitude. The vertical distance of a level, a point or an object considered as a point, measured from mean sea level (MSL).

Application schema. Conceptual schema for data required by one or more applications.

Apron. A defined area, on a land aerodrome, intended to accommodate aircraft for purposes of loading or unloading passengers, mail or cargo, fuelling, parking or maintenance.

Arresting gear location. Location of the arresting gear cable across the runway.

Assemble. A process of merging data from multiple sources into a database and establishing a baseline for subsequent processing.

Note.— The assemble phase includes checking the data and ensuring that detected errors and omissions are rectified.

Bare earth. Surface of the Earth including bodies of water and permanent ice and snow, and excluding vegetation and man-made objects.

Blunder errors. From the statistical point of view, blunders or mistakes are observations that cannot be considered as belonging to the same sample from the distribution in question. They should not be used with other observations. They should be located and eliminated.

Canopy. Bare earth supplemented by vegetation height.

Circular error probability (CEP). CEP refers to the radius of a circle within which a stated percentage of measurements for a given point will fall. For example, if the horizontal accuracy of a surveyed point is stated as 1 m with 90% CEP, then 90% of measurements of this point will fall within a circle of 1 m radius. The true position is then estimated to lie at the centre of this circle.

Note.— For GPS, CEP is usually stated at 50%.

Clearway. A defined rectangular area on the ground or water under the control of the appropriate authority, selected or prepared as a suitable area over which an aeroplane may make a portion of its initial climb to a specified height.

Completeness. The primary quality parameter describing the degree of conformance of a subset of data compared to its nominal ground with respect to the presence of objects, associations instances, and property instances.

Computer-based systems. Systems operating from pre-assembled aeronautical databases. Systems include, but are not limited to, area navigation systems, flight management systems, flight planning systems, flight simulators, computer modelling and design systems.

Conceptual model. Model that defines the concepts of a universe of discourse.

Conceptual schema. Formal description of a conceptual model.

Conceptual schema language. Formal language based on a conceptual formalism for the purpose of representing conceptual schemas.

Confidence. Meta-quality element describing the correctness of quality information.

Confidence level. The probability that the true value of a parameter is within a certain interval around the estimate of its value. The interval is usually referred to as the accuracy of the estimate.

Coordinate reference system. Coordinate system that is related to the real world by a datum.

Coordinate system. Set of mathematical rules for specifying how coordinates are to be assigned to points

Construction area. Part of a movement area under construction.

Correct data. Data meeting stated quality requirements.

Corruption. A change to previously correct data introduced during processing, storage, or transmission, which causes the data to no longer be correct.

Coverage. A feature that acts as a function to return one or more feature attribute values for any direct position within its spatiotemporal domain.

Coverage geometry. Configuration of the spatiotemporal domain of a coverage described in terms of coordinates.

Cultural features. Manmade morphological formations that include transportation systems (roads and trails; railroads and pipelines; runways; transmission lines), and other manmade structures, (buildings, houses, schools, churches, hospitals).

Culture. All man-made features constructed on the surface of the Earth, such as cities, railways and canals.

Cyclic redundancy check (CRC). A mathematical algorithm applied to the digital expression of data that provides a level of assurance against loss or alteration of data.

Database. One or more files of data so structured that appropriate applications may draw from the files and update them.

Note.— This primarily refers to data stored electronically and accessed by computer rather than in files of physical records.

Data element. A term used to describe any component of an AMDB. For example: a feature, an attribute, an object, an entity, or a value.

Data integrator. The part of an organisation, which takes data from one or more sources to produce a terrain or obstacle database that satisfies a particular specification.

Data originator. The part of an organisation which performs measurements by a particular means and which then groups those measurements to represent an area of terrain or a set of obstacles.

Data product. Data set or data set series that conforms to a data product specification.

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.

Note.— A data product specification provides a description of the universe of discourse and a specification for mapping the universe of discourse to a data set. It may be used for production, sales, end-use or other purpose.

Data quality. A degree or level of confidence that the data provided meet the requirements of the data user in terms of accuracy, resolution and integrity.

Data set. Identifiable collection of data.

Data set series. Collection data sets sharing the same product specification.

Data type. Specification of the legal value domain and legal operations allowed on values in this domain.

Datum. Any quantity or set of quantities that may serve as a reference or basis for the calculation of other quantities.

Deficiency. The aeronautical data process is not adequate to ensure that data quality requirements are satisfied.

De-icing/anti-icing pad. An area comprising an inner area for the parking of an aeroplane to receive de-icing/anti-icing treatment and an outer area for the manoeuvring of two or more mobile de-icing/anti-icing equipment.

Digital Elevation Model (DEM). The representation of terrain surface by continuous elevation values at all intersections of a defined grid, referenced to common datum.

Note.— Digital Terrain Model (DTM) is sometimes referred to as DEM.

Digital ortho-rectified imagery. Digital aerial photography or satellite imagery that has been matched, or registered, to a surveyed ground control coordinate system and to spatially corresponding elevation data. Directions, angles, and distances are all to scale. A digital ortho-rectified image, therefore, is

one whose coordinates have been adjusted to match its corresponding ground position, including adjustment for the effects of terrain undulations.

Digital surface model. Digital model of the topographic surface, including vegetation and man-made structures.

Displaced threshold. A threshold not located at the extremity of a runway.

Distribution (paper). The process of disseminating documents containing formatted aeronautical data in various media, including the shipping and loading of a database into the target system for application.

Distribution (data). The process of duplication of formatted aeronautical data into a database and the shipping and loading of the database into the target system for application. Distribution is usually achieved by transferring the data from one medium to another, with each transfer being verified.

Domain. Well-defined set.

Note.— Well-defined means that the definition is both necessary and sufficient, as everything that satisfies the definition is in the set and everything that does not satisfy the definition is necessarily outside the set.

Draping. Digital overlaying of one spatial data set onto another, where both data sets have been georectified (digitally matched) to the same coordinate system and map projection. Particularly useful in 3D visualizations of spatial data. Example: draping a satellite image over terrain data and creating a fly-through visualization in motion.

Elevation. The vertical distance of a point or a level, on or affixed to the surface of the earth, measured from mean sea level.

Ellipsoid height (Geodetic height). The height related to the reference ellipsoid, measured along the ellipsoidal outer normal through the point in question.

End-user. An ultimate source and/or consumer of information.

Enterprise data. Common data used by multiple users but stored at a single location.

Error. Defective or degraded data elements or lost or misplaced data elements or data elements not meeting stated quality requirements.

Feature. Abstraction of real-world phenomena.

Feature association. Relationship between features.

Note 1.— A feature association may occur as a type or an instance. Feature association type or feature association instance is used when only one is meant.

Note 2.— Feature associations include aggregations of features.

Feature attribute. Characteristic of a feature.

Note.— A feature attribute has a name, a data type and a value domain associated with it.

Feature catalogueue. Catalogueue containing definitions and descriptions of the feature types, feature attributes, and feature relationships occurring in one or more sets of geographic data, together with any feature operations that may be applied.

Final approach and take-off area (FATO) A defined area over which the final phase of the approach manoeuvre to hover or landing is completed and from which the take-off manoeuvre is commenced. Where the FATO is to be used by performance Class 1 helicopters, the defined area includes the rejected take-off area available.

Format. The process of translating, arranging, packing, and compressing a selected set of data for distribution to a specific target system.

Frequency area. Designated part of a surface movement area where a specific frequency is required by air traffic control or ground control.

Geodetic datum. A minimum set of parameters required to define location and orientation of the local reference system with respect to the global reference system/frame.

Geodetic distance. The shortest distance between any two points on a mathematically defined ellipsoidal surface.

Geographic coordinates. The values of latitude, longitude, and height that define the position of a point on the surface of the Earth with respect to a reference datum.

Geographic data. Data with implicit or explicit reference to a location relative to the Earth.

Note.— Geographic information is also used as a term for information concerning phenomena implicitly or explicitly associated with a location relative to the Earth.

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.

Note.— The geoid is irregular in shape because of local gravitational disturbances (wind tides, salinity, current, etc.) and the direction of gravity is perpendicular to the geoid at every point.

Geoid undulation. The distance of the geoid above (positive) or below (negative) the mathematical reference ellipsoid.

Note.— In respect to the World Geodetic System — 1984 (WGS-84) defined ellipsoid, the difference between the WGS-84 ellipsoidal height and orthometric height represents WGS-84 geoid undulation.

Global navigation satellite system (GNSS). A worldwide position and time determination system that includes one or more satellite constellations, aircraft receivers and system integrity monitoring, augmented as necessary to support the required navigation performance for the intended operation.

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.

Note.— In the Gregorian calendar, common years have 365 days and leap years 366 days divided into twelve sequential months.

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

Helipad. A small designated area, usually with a prepared surface, on a heliport, aerodrome, landing/take-off area, apron area, or movement area used for take-off, landing, or parking of helicopters.

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.

Imagery. The product of photography or advanced imaging sensors. Can be produced via either aerial or satellite fly-overs.

Integrity (aeronautical data). A degree of assurance that an aeronautical data and its value has not been lost or altered since the data origination or authorized amendment.

Land and hold short operations (LAHSO) location. Marking used for land and hold short operations (LAHSO).

Line. A connected sequence of points.

Linear Error Probability (LEP). A linear magnitude within which a stated percentage of measurements for a given point will fall. For example, if the vertical accuracy of a surveyed point is stated as 1 m with 90% LEP, then 90% of measurements of the height of this point will fall along a vertical line of length 1 m. The true position is then estimated to lie at the center of this vertical line.

Note.— *LEP is the one-dimensional form of CEP.*

Manoeuvring area. That part of an aerodrome to be used for the take-off, landing and taxiing of aircraft, excluding aprons.

Marking. A symbol or group of symbols displayed on the surface of the movement area in order to convey aeronautical information.

Mean sea level (MSL). The average location of the interface between the ocean and the atmosphere, over a period of time sufficiently long so that all random and periodic variations of short duration average to zero. [FAA doc. 405]

Metadata. Data about data.

Note.— *Data that describes and documents data.*

Model. Abstraction of some aspects of reality.

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(s).

Multi-ring polygon. One or more polygons located inside another polygon that excludes the area of the inner polygons (e.g. doughnut, figure eight).

NOTAM. A notice distributed by means of telecommunication containing information concerning the establishment, condition, or change in any aeronautical facility, service, procedure, or hazard, the timely knowledge of which is essential to personnel concerned with flight operations.

Obstacle. All fixed (whether temporary or permanent) and mobile objects, or parts thereof, that are located on an area intended for the surface movement of aircraft or that extend above a defined surface intended to protect aircraft in flight.

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

Originate. The process of creating a data item or amending the value of an existing data item.

Originator (data). The first organization in the aeronautical data chain that accepts responsibility for the data.

Orthometric height. Height of a point related to the geoid, generally presented as an MSL elevation.

Painted centerline. Continuous line along the painted line in the center of a runway connecting the two thresholds.

Pavement classification number (PCN). A number expressing the bearing strength of a pavement for unrestricted operations.

Point. The smallest unit of geometry which has no spatial extent. Points are described by two-dimensional (2D) or three-dimensional (3D) coordinates.

Polygon. A surface or area described by a closed line.

Portrayal. Presentation of information to humans.

Position (geographical). Set of coordinates (latitude and longitude) referenced to the mathematical reference ellipsoid that define the position of a point on the surface of the Earth.

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

Precision. The smallest difference that can be reliably distinguished by a measurement process.

Note.— In reference to geodetic surveys, precision is a degree of refinement in performance of an operation or a degree of perfection in the instruments and methods used when making measurements.

Quality. Degree to which a set of inherent characteristics fulfils requirements.

Note 1.— The term “quality” can be used with adjectives such as poor, good or excellent.

Note 2.— “Inherent”, as opposed to “assigned”, means existing in something, especially as a permanent characteristic.

Quality assurance. Part of quality management focused on providing confidence that quality requirements will be fulfilled.

Radiometric resolution. The capability of a sensor to discriminate levels or intensity of spectral radiance. In the analogue systems such as photography, the radiometric resolution is measured based on the number of grey levels that can be obtained. In opto-electronic systems, the radiance is recorded in an array of cells. A digit is assigned to each cell proportional to the received level of energy. This is done by an analog to digital converter in the platform. Generally, in modern sensors the range is between zero radiance into the sensor and 255 at saturation response of the detector.

Ramp. See apron.

Random errors. Random errors of observations refer to the basic inherent property that estimates of a random variable do not agree, in general, with its expectation.

Reference Ellipsoid. A geometric figure comprising one component of a geodetic datum, usually determined by rotating an ellipse about its shorter (polar) axis, and used as a surface of reference for geodetic surveys. The reference ellipsoid closely approximates the dimensions of the geoid, with certain ellipsoids fitting the geoid more closely for various areas of the earth. Elevations derived directly from satellite observations are relative to the ellipsoid and are called ellipsoid heights.

Repeatability. The closeness with which a measurement upon a given, invariant sample can be reproduced in short-term repetitions of the measurement with no intervening instrument adjustment.

Required navigation performance (RNP). A statement of the navigation performance necessary for operation within a defined airspace.

Note.— Navigation performance and requirements are defined for a particular RNP type and/or application.

Resolution. A number of units or digits to which a measured or calculated value is expressed and used.

Runway. A defined rectangular area on a land aerodrome prepared for the landing and take-off of aircraft.

Runway displaced area. That portion of a runway between the beginning of the runway and the displaced threshold.

Runway exit line. Guidance line painted on the runway exit.

Runway end safety area (RESA). An area symmetrical about the extended runway centre line and adjacent to the end of the strip primarily intended to reduce the risk of damage to an aeroplane undershooting or overrunning the runway.

Runway holding position. A designed position intended to protect a runway, an obstacle limitation surface, or an ILS/MLS critical/sensitive area at which taxiing aircraft and vehicles shall stop and hold, unless otherwise authorized by the aerodrome control tower.

Runway intersection. Intersecting area of two or more runways.

Schema. Formal description of a model.

Seaplane landing area (SLA). A defined area on water at an aerodrome prescribed for the landing and take-off of seaplanes.

Seaplane landing lane (SLL). A defined path on water at an aerodrome prescribed for the landing and take-off run of seaplanes along its entire length.

Service road. Part of aerodrome surface that must be used only by service vehicles and is not considered as surface movement areas for aircraft.

Shoulder. An area adjacent to the edge of a pavement so prepared as to provide a transition between the pavement and the adjacent surface.

Situational awareness. The perception of elements in the environment, the comprehension of their meaning, and the projection of their status into the near future. [Endsley, 1990] For example, for pilots, the elements of the environment include, but are not limited to, the crew, passengers, aircraft systems, time, position, weather, traffic, and ATC constraints.

Spatial resolution. The capacity of the system (lens, sensor, emulsion, electronic components, etc.) to define the smallest possible object in the image. Historically, this has been measured as the number of lines pair per millimetre that can be resolved in a photograph of a bar chart. This is the so-called analogue resolution. For the modern photogrammetric cameras equipped with forward motion compensation (FMC) devices and photogrammetric panchromatic black and white emulsions, the resolution could (depending on contrast) be 40 to 80 lp/mm (line pairs per millimetre).

Specification. Document which establishes the requirements the product or service should be compliant with.

Spectral resolution. The capability of a sensor to discriminate the detected radiance in different intervals of wavelengths of the electromagnetic spectrum. Hence, the spectral resolution is determined by the number of bands that a particular sensor is capable to capture and by the corresponding spectral bandwidth.

Stand. See aircraft stand.

State. An internationally recognized geographic entity that provides aeronautical information service.

Stopway. A defined rectangular area on the ground at the end of take-off run available prepared as a suitable area in which an aircraft can be stopped in the case of an abandoned take-off.

Surface lighting. Lighting within a movement area.

Survey control point. A monumented survey control point.

Systematic errors. Systematic errors affect all repeated observations in the same way. Systematic errors are often referred to as bias errors. These effects can be minimized via instrument calibration and/or the use of the appropriate math model.

Taxiway. A defined path on a land aerodrome established for the taxiing of aircraft and intended to provide a link between one part of the aerodrome and another, including:

- a) *Aircraft stand taxilane.* A portion of an apron designated as a taxiway and intended to provide access to aircraft stands only.
- b) *Apron taxiway.* A portion of a taxiway system located on an apron and intended to provide a through taxi route across the apron.

- c) **Rapid exit taxiway.** A taxiway connected to a runway at an acute angle and designed to allow landing aeroplanes to turn off at higher speeds than are achieved on other exit taxiways thereby minimizing runway occupancy times.

Taxiway guidance line. Guidance line painted on a taxiway.

Taxiway holding position. A designated position at which taxiing aircraft and vehicles must stop and hold position, unless otherwise authorized by the aerodrome control tower.

Taxiway intersection. A junction of two or more taxiways.

Taxiway intersection marking. Taxiway intersection marking painted across a taxiway.

Temporal resolution. The periodicity through which a sensor can acquire a new image of the same spot of the Earth's surface.

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

Note.— In practical terms depending on the method of data collection, terrain represents the continuous surface that exists between the bare Earth and the top of the canopy (or something in between also known as “first reflective surface”).

Threshold. The beginning of that portion of the runway useable for landing.

Touchdown zone (TDZ). The portion of a runway, beyond the threshold, where it is intended landing aeroplanes first contact the runway.

Touchdown and lift-off area(TLOF). A load bearing area on which a helicopter may touchdown or lift-off.

Traceability. Ability to trace the history, application or location of that which is under consideration.

Note .— When considering product, traceability can relate to

- the origin of materials and parts,*
- the processing history,*
- the distribution and location of the product after delivery.*

Universe of discourse. View of the real or hypothetical world that includes everything of interest.

User of aeronautical data. The group or organization using the system that contains the delivered aeronautical data on an operational basis, such as the airline operator.

Note.— The user may also be referred to as the “end user”.

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

Note 1.— The term “validated” is used to designate the corresponding status.

Note 2.— The use conditions for validation can be real or simulated.

Verification. Confirmation, through the provision of objective evidence that, specified requirements have been fulfilled.

Note 1.— The term “verified” is used to designate the corresponding status.

Note 2.— Confirmation can comprise activities such as

- performing alternative calculations,*
- comparing a new design specification with a similar proven design specification,*

- *undertaking tests and demonstrations, and*
- *reviewing documents prior to use.*

Vertex. A point that defines a line structure, curvature, or shape.

Vertical line structure. Line structure of a defined vertical extend that is located within an area that extends from the edge(s) of the runway(s) to 90 m from the runway centreline(s) and for all other parts of the aerodrome movement area(s), 50 m from the edge(s) of the defined area(s).

Vertical object. An object with vertical extent that is within the designated buffer area.

Vertical point structure. Point structure of a defined vertical extend that is located within an area that extends from the edge(s) of the runway(s) to 90 m from the runway centreline(s) and for all other parts of the aerodrome movement area(s), 50 m from the edge(s) of the defined area(s).

Vertical polygonal structure. Polygonal structure of a defined vertical extend that is located within an area that extends from the edge(s) of the runway(s) to 90 m from the runway centreline(s) and for all other parts of the aerodrome movement area(s), 50 m from the edge(s) of the defined area(s).

Acronyms

ACARS	Aircraft Communications Addressing and Reporting System
ACR	Avionics Computer Resource
ADS-B	Automatic Dependent Surveillance - Broadcast
AFM	Aeroplane Flight Manual
AGL	Above Ground Level
AIP	Aeronautical Information Publication
AIRAC	Aeronautical Information Regulation and Control
AIS	Aeronautical Information Service
AIXM	Aeronautical Information Exchange Model
ALAR	Approach and Landing Accident Reduction
ALP	Airport Layout Plan
ALSF-2	High Intensity Approach Lighting with Sequenced Flashing Lights
AMDB	Aerodrome Mapping Database
ARINC	Aeronautical Radio Inc
ARP	Aerodrome Reference Point
ASCII	American Standard Code for Information Interchange
A-SMGCS	Advanced Surface Movement Guidance and Control System
ATC	Air Traffic Control
ATIS	Automatic Terminal Information Service
ATM	Air Traffic Management
BITE	Built-In Test Equipment
CAA	Civil Aviation Authority
CAD	Computer-Aided Design
CCD	Charge Coupled Device
CEP	Circular Error Probability
CFIT	Controlled Flight Into Terrain
CNG	Change
CNL	Cancel
CNS	Communication Navigation Surveillance
CPDLC	Controller-Pilot Data Link Communications
CRC	Cyclic Redundancy Check
DEM	Digital Elevation Model
DEP	Departure

DLA	Delay
DORI	Digital Ortho-Rectified Imagery
DPS	Data Product Specification
DSM	Digital Surface Model
DTM	Digital Terrain Model
ED	EUROCAE Document
EGM	Earth Gravitational Model
EGM-96	Earth Gravitational Model 1996
EPSG	European Petroleum Survey Group
ETRF	European Terrestrial Reference Frame
EUROCAE	European Organization for Civil Aviation Equipment
EUROCONTROL	European organization for safety of air navigation
FAA	Federal Aviation Administration
FAR	FAA Aviation Regulation
FATO	Final Approach and Take-off areas
FHA	Functional Hazard Analysis
FPL	Filed Flight Plan
FMC	Forward Motion Compensation
GIS	Geographic Information System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
ICAO	International Civil Aviation Organization
IERS	International Earth Reference System
IFSAR	Interferometric Synthetic Aperture Radar
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
INS	Inertial Navigation System
ISO	International organisation for standardisation
JAA	Joint Aviation Authority
LAAS	Local Area Augmentation System
LAHSO	Land and Hold Short Operations
LEP	Linear Error Probability
LIDAR	Light Detection and Ranging
MEF	Maximum Elevation Figures
MSA	Minimum Sector Altitude

MSAW	Minimum Safe Altitude Warning
MSL	Mean Sea Level
MVA	Minimum Vector Altitude
N/A	Not Applicable
NAD-83	North American Datum 1983
NGA	National Geospatial-Intelligence Agency
NM	Nautical mile
NMI	Nautical mile
NOAA	National Oceanographic and Atmospheric Administration
NOTAM	Notice to Airmen
NS	Not specified
OIS	Obstacle Identification Surface
PANS-OPS	Procedures for Air Navigation Services - Aircraft Operations
PCN	Pavement Classification Number
PDF	Probability Density Function
PMC	Program Management Committee
RIPS	Runway Incursion Prevention System
RNAV	Area Navigation
RNP	Required Navigation Performance
SA	Situational awareness
SAE	Society of Automotive Engineers
SAR	Synthetic Aperture Radar
SARPs	Standards and Recommended Practices
SC	Special Committee
STAR	Standard Terminal Arrival Route
SUA	Special Use of Airspace
SVS	Synthetic Vision System
TAWS	Terrain Awareness Alerting System
TCAS	Traffic Alerting and Collision Avoidance System
TCP/IP	Transmission Control Protocol/Internet Protocol
TERPS	US standard for Terminal Instrument Procedures
TIN	Triangular Irregular Network
TIS-B	Traffic Information Service – Broadcast
TLOF	Touchdown Lift-off areas
TMA	Terminal Area

TSO	Technical Standard Order
UDDF	Universal Data Distribution Format
UID	Unique object Identifier
UML	Unified Modelling Language
USGS	United States Geological Survey
UTC	Universal coordinated time
UTM	Universal Transverse Mercator
UUID	Universal Unique Identifier
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions
VOR	Very High Frequency Omni-directional Radio Range
WG	Working Group
W3C	World Wide Web Consortium
WGS-84	World Geodetic System - 1984
XML	Extensible Mark-up Language

1 Document Overview

1.1 *Electronic terrain and obstacle data*

Significant safety benefits for international civil aviation will be provided by in-flight and ground-based applications that rely on quality electronic terrain and obstacle data. The increasing worldwide equipage of aircraft and air traffic control units with systems that make use of electronic terrain data requires standardization in the provision of supporting data. Furthermore, as terrain information is increasingly finding its primary usage in the cockpit, many other personnel involved with operations will also benefit from the use of quality terrain and obstacle data. The performance of these applications that often make use of multiple data sources, however, may be degraded by data with inconsistent or inappropriate specifications for quality.

The new provisions in Annex 15 on the subject of electronic terrain and obstacle data are based on work done by ICAO together with EUROCAE WG 44 and RTCA SC 193 and comments received from States during the Annex 15 amendment process. These new Annex 15 provisions deal with the electronic terrain and obstacle data function, coverage, terrain and obstacle numerical requirements, content and structure of terrain and obstacle databases, data product specifications for terrain and obstacle data and their availability. In addition, applications for which quality terrain and obstacle data, used in conjunction with aeronautical data, are required, have also been identified.

To satisfy identified user requirements for electronic terrain and obstacle data, while taking into account cost-effectiveness, acquisition methods and data availability, the data are to be provided according to four basic coverage areas (paragraphs 10.2.1 to 10.2.4 of Annex 15 refer). Area 1 has a coverage over the whole territory of a State, including aerodromes/heliports. Area 2 covers the established terminal control areas, not exceeding a 45 km radius from the aerodrome reference point (ARP), to coincide with the existing specification for the provision of topographical information on the Aerodrome Obstacle Chart — ICAO Type C (Annex 4, paragraph 5.3.1 c) refers). Area 3 covers the area which is within the specified distances from the edges of a defined aerodrome or heliport surface movement area while Area 4 is restricted for use only for those runways where precision approach Category II or III operations have been established.

For each of the four areas, numerical requirements for terrain and obstacle data have been defined in Annex 15, Appendix 8, Tables A8-1 and A8-2, respectively. As indicated in the notes to 10.2.5 of Annex 15, numerical terrain and obstacle data requirements for Area 2 are defined on the basis of the most stringent application requirement, i.e. determination of contingency procedures for use in the event of an emergency during a missed approach or take-off. It is recognized, however, that some applications listed in 10.1.1 of Annex 15 and Chapters 2 and 3 of this manual, could be adequately accommodated with terrain and obstacle data sets that are of lower requirements than those specified in Appendix 8 of Annex 15 and which are readily available from States or other authorized data producers today. Consequently, careful evaluation by data users of available data sets will be necessary in order to determine if the products will fit their intended use.

The provisions in Annex 15, concerning terrain database and obstacle database contents and structures are defined as two separate databases. There are several reasons for this division which include, different acquisition methods and established maintenance periods of data. It is recognized that depending on the acquisition method, the description of the terrain contained in the database could be the bare earth, the top of vegetation (canopy) or something in between.

Paragraph 10.5.2 of Annex 15 contains details regarding the provision of terrain and obstacle data product specifications on the basis of the ISO 19131 standard. Terrain and obstacle data product specifications are comprehensive statements regarding available electronic and obstacle data sets on which basis air navigation users will be able to evaluate the products and determine if any of them satisfy the requirements for their intended use in a particular application. Data product specification is intended to support information interchange between interested parties by providing feature types, feature attributes, geometry and attribute encoding rules, maintenance, quality requirements and metadata.

Successful interchange of data sets implies delivery, receipt and interpretation of data among the communicating parties and this interchange could be achieved through data set transfer. One interchange process is based upon a common application schema known to both suppliers and users of data. Data sets are transformed into the common transfer format based upon an encoding process that is defined by mapping between an application schema of a supplier and the common application schema. In a similar manner, decoding by the user of a common transfer data set format would generate data for the user. The above represents the fundamental principle for data interchange that would be applied to terrain and obstacle data interchange and onward use of data for different applications. On the basis of this principle, more complex and fully automated data interchange mechanisms may be built using a network to communicate messages requesting data on which basis corresponding delivery of requested data will be made. This type of interaction-based process represents an extension of the fundamental interchange principle and would lead to a dynamic (real-time) interchange of terrain and obstacle data. Therefore, the Standards in Annex 15 for terrain and obstacle data interchange represent a conceptual step towards networked interoperability aimed at an XML-based implementation of the data set transfer model.

1.2 Aerodrome mapping information

At large aerodromes, many activities are performed by number of participants such as pilots, airline operations personnel, general aviation operations personnel, air traffic controllers, apron controllers, surface vehicle operators, construction/maintenance crews, emergency/security personnel, etc. All the participants involved, must cooperate closely, to ensure safe and efficient flight operations at the aerodrome and for this purpose they must be knowledgeable of the aerodrome layout.

For all the activities by the different users detailed aerodrome geospatial information is required. This information is commonly made available in aerodrome mapping databases (AMDBs). These databases contain aerodrome information that is organized and arranged for ease of electronic storage and retrieval in systems that support a range of activities on and around the aerodrome.

Amendment 33 to Annex 15 did not address specifically the aerodrome mapping information by providing new specifications since those provisions are already contained in Annex 4, Annex 14, Volumes I and II and in Annex 15. Those provisions are in the form of aeronautical data quality requirements prescribed for specific aerodrome design characteristics and their presentation in State Aeronautical Information Publication (AIP) in the textual or graphical form. Chapter 4 of this manual provides a complete guidance for the aerodrome surface mapping information required for aeronautical users and particularly for on-board aircraft use. The guidance included in Chapter 4 provides minimum requirements and reference material for the content, origination, publication, maintenance and enhancements of aerodrome mapping information. It also provides a comprehensive statements regarding available aerodrome mapping information data sets in the form of the data product specification. This specification is intended for use by air navigation users when evaluating the products and determining if they satisfy requirements for use in a particular application.

1.3 Application of this manual

1.3.1 Assumptions

Any terrain, obstacle and aerodrome mapping data to be used to support aeronautical applications must meet the requirements defined in Annex 15 and detailed in this document. The aim of this document is to provide guidelines regarding the requirements that should be applied along data chain in order to obtain a database commensurate with the criticality of the final application of the data. The data requirements provided in this document will not affect existing standards being used for data acquisition, however, in some cases because of stringent accuracy and integrity requirements, traditional validation procedures may require modifications to accommodate quality requirements.

As a first step, each individual State, appropriate delegated agencies or private organisations originate the data. It is beyond the scope of this document to mandate requirements on the originators of such data (derived from topographic survey, satellite imagery, etc.) as it is understood that they already follow clearly identified professional standards, specific requirements and methodologies. Nevertheless, it is recognized that quality requirements derived from the system designer or the end user specifications may be equally applicable to the data originator.

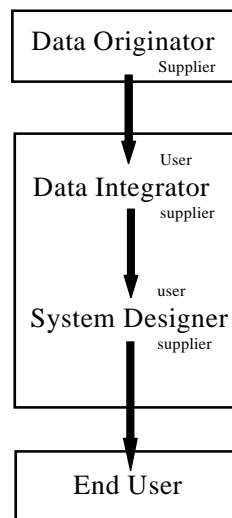


Figure 1-1. Data flow from supplier to user

Once originated, data may exist in different formats and have different quality characteristics and these data are transmitted to the data integrators, who then merge the data received. The data will then be passed to the system designer for integration into the end-user system.

It is recognized there are data that do not meet the stipulated numerical requirements or geographic coverage for a given area. Such data are still useful to the aeronautical community¹ provided the necessary quality characteristics in this document are specified. Such data should be clearly annotated to identify which values do not meet the quality characteristics, numerical requirements, or geographic coverage for a given area.

It is assumed that not all applications will require a complete set of data or all data types to enable their intended use. Requirements specified in this document need only be complied with for those data that are

¹ Such data can, amongst many other uses, support systems which require less stringent data than that specified in this document or to infill data omissions.

needed for an application. Figure 1-2 further details the data integration processes that contribute to the development of an terrain, obstacle or aerodrome mapping database.

1. Data originators, collect the terrain, obstacle or aerodrome mapping data using aerial photography, laser scanning, satellite information, topographical surveys, etc.. Certain existing data may have to be modified (e.g. resurveyed) to satisfy stringent accuracy and integrity requirements (Requirements A in Figure 1-2). The data from different data originators are *supplied* to data integrators.

2. Data integrators, use the data sets supplied by the originators, manipulate to integrate the data sets to ensure full data (terrain, obstacle, aerodrome mapping) coverage in accordance with the required accuracy and integrity. The data sets are *supplied* to the system designers.

3. System designers, (e.g. avionics manufacturers) use and if necessary merge specific data sets provided by multiple data integrators to meet the requirements of a specific application. Some of these requirements (illustrated as Requirements B in Figure 1-2) are also defined in this document. The data set are then *supplied* to the end users (End User Pool in Figure 1-2).

4. End users, which consist of Aircraft Operators, Civil Aviation Authorities, Aerodrome Authorities, Aircraft/Avionics manufacturers etc, use and validate the data sets as applicable.

At each of the above steps of the process, it is the responsibility of the user to ensure that the data received meets the requirements for its intended application.

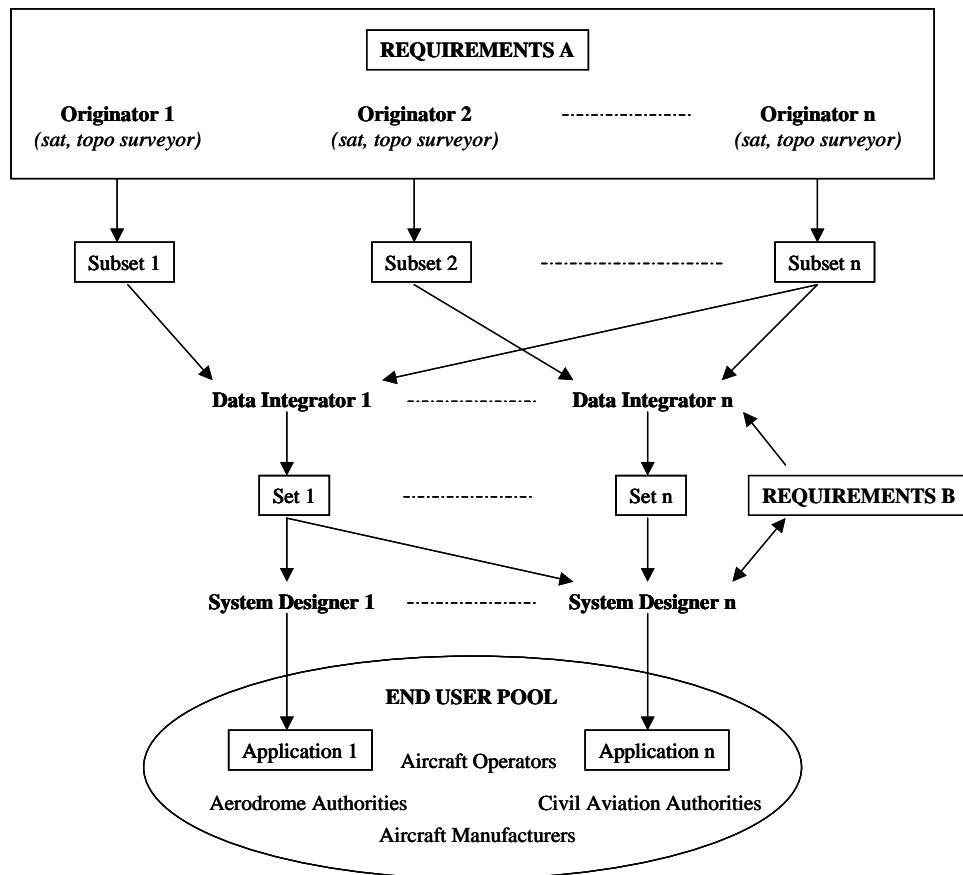


Figure 1-2. Data integration processes from origination to end use

1.4 Data Exchange

1.4.1 Scope

This guidance describes requirements for the interchange of geographic data products that represent terrain, obstacles, and aerodrome mapping features. These requirements apply the concepts of the ISO 19100 series of standards to previously published requirements for data content and quality. Specifically, this guidance represents an intermediate specification level between abstract conceptual requirements and a compliant interchange implementation (Figure 1-3).

It is not the intent of this interchange guidance to impose any physical interchange format on the user. This is solely to be agreed upon by the involved interchange parties.

Feature relationships, data capture rules, and structural constraints are not considered within the scope of the data interchange guidance. It is assumed that they are applied in accordance with this manual during the data production process. It is the responsibility of a given data interchange implementation to ensure that structural requirements are met.

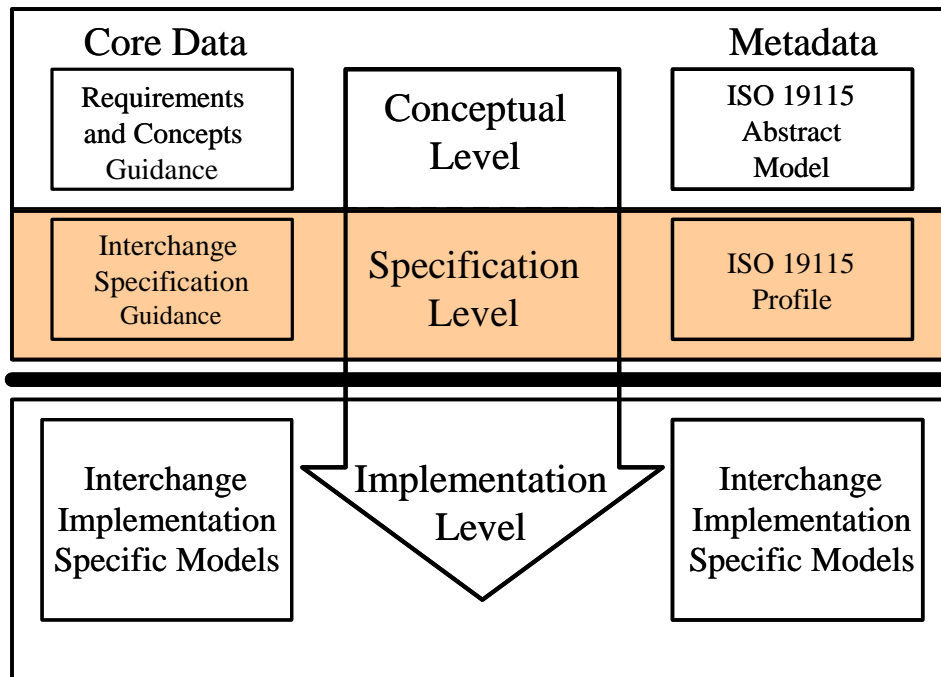


Figure 1-3. Scope of interchange guidance (shaded area)

1.4.2 Introduction

Improved common situational awareness and applications such as Ground Proximity Warning Systems (GPWS), advanced navigation displays, taxi situational awareness displays, Runway Incursion Prevention Systems (RIPS), and Synthetic Vision Systems (SVS) will enhance the safety and efficiency of aircraft operations in-flight, during approach/take-off, and while manoeuvring on the aerodrome surface. These systems are information-dependent and must use accurate, reliable, and up-to-date terrain, obstacle, and aerodrome mapping data. This implies an interchange process between data originators, integrators, and users based on common agreed-upon information interchange formats. These formats will constitute a foundation upon which the tailored end-user applications may be built.

1.4.3 Data Set Transfer

Successful data interchange implies delivery, receipt, and interpretation of data among communicating parties. This may be achieved by two approaches:

- a) data interchange by data set transfer
- b) data interchange by transaction or message

These interchange guidelines are addressing the data set transfer approach (Figure 1-4). This approach requires an interchange process that is based upon a **common application schema** known by the suppliers and users who intend to exchange information. Data are transformed into a common transfer format based upon an encoding process that is defined by a mapping between the supplier application schema and the common application schema. A similar mechanism decodes the common transfer data set to generate the user data. This model is suitable for base map data that constitute the fundamental part of the total information interchange needed in the context of terrain, obstacle, and aerodrome mapping data.

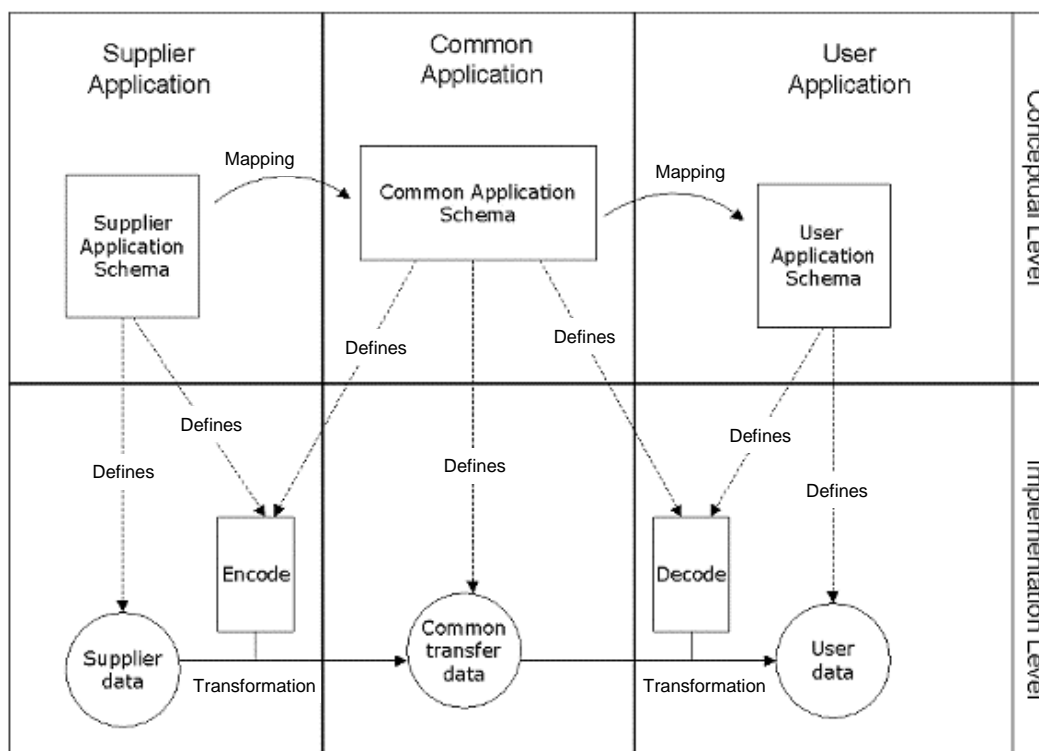


Figure 1-4. Data set transfer approach

1.4.4 Interchange Guidance

A common database interchange guidance for terrain, obstacle, and aerodrome mapping databases is a key success factor for the implementation of digital functions in the aviation domain. It enables a common interchange between data originators, data integrators, system designers and data users and it increases efficiency and safety.

This document specifies the user requirements for terrain, obstacle, and aerodrome database content and quality and sets guidelines and requirements to develop a data interchange format for terrain, obstacle,

and aerodrome data. These interchange guidelines were generated on the basis of the ISO 19100 (geographic information) series of standards as applied to terrain, obstacle, and aerodrome mapping databases that are to be used in aviation. It, therefore, contains ISO compliant data product specifications (DPS) for terrain, obstacle, and aerodrome mapping databases that are to be interchanged. Generally, DPS establishes a basis that can be used by data originators, data integrators, and system designers to implement a physical interchange format. Interoperability among different physical formats can be facilitated by complying with these guidelines.

1.4.5 General structure and content of a Data Product Specification (DPS)

A data product specification (DPS) defines the requirements for a data product. A DPS content is intended to assist potential users to evaluate the data product to determine its fitness for their use. The information contained in a DPS is different from the one contained in metadata for the same data set. The later provides information about a particular physical data set. Information from the DPS may be used in the creation of metadata for a particular data set that is created in conformance with that DPS. Thus, metadata describes how a data set actually is, while a DPS describes how it should be. DPS contains information that enable data discovery prior to data interchange. As such, all DPS elements are not necessarily part of the physical interchange.

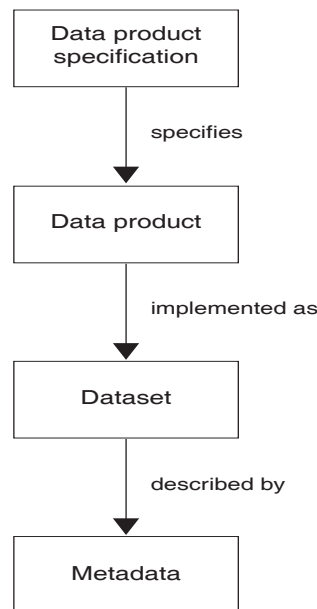


Figure 1-5. Relationship between a DPS and metadata

In this document, Chapter 2 (terrain), Chapter 3 (obstacles), and Chapter 4 (aerodrome mapping) provide three separate DPSs to enable the interchange of terrain, obstacle, and aerodrome mapping data for aviation applications. The structure and content of each DPS is based on the ISO 19131 template. In a similar manner, the structure and coding specifications of the feature catalogues for obstacles and aerodrome mapping data are based on ISO 19110, while the metadata specifications are based on ISO 19115.

For terrain, obstacle, and aerodrome mapping DPSs, the following sub-sections are included:

- » Overview of the data product
- » Specification scopes

- » Data product identification
- » Data content and structure
- » Reference systems
- » Data quality
- » Data capture
- » Data maintenance
- » Portrayal
- » Data product delivery
- » Additional information
- » Metadata

Note: For a DPS there are mandatory and optional information elements specified. When an mandatory information element is included as part of a DPS, it must be provided according to the stated specifications. Appendix E contains an example of a DPS.

1.4.6 Reference systems

World Geodetic System – 1984 (WGS-84) is the adopted aviation standard for horizontal reference system while Mean Sea Level (MSL) is the adopted vertical reference system. MSL elevations can be derived using an appropriate geoid model. The Earth Gravitational Model (EGM-96) is the adopted global geoid model. Gregorian calendar and Coordinated Universal Time (UTC) are adopted as temporal reference system.

Consequently, the horizontal reference for all position terrain, obstacle and aerodrome mapping data must be the WGS-84 ellipsoid. In all those cases where data sets already exist and are based on a different reference system, they must be transformed to the WGS-84. In this sense different approaches may be chosen, among them the use of the *Unabridged Modelenskii Series* or the *Rigorous Solution* that is based on a seven-parameter three-dimensional transformation. This contemplates three shifts of the centre of the old to the new ellipsoid, three rotations of the old to the new ellipsoid, and one scale factor relating possible local deformations of the old system. If it is decided to apply the *Rigorous Solution* this should contemplate the local geoid undulations during the computations of the Cartesian coordinate system. Data quality must be preserved when performing coordinate system conversions.

All terrain, obstacles or aerodrome mapping data that includes horizontal position information must be described in units of latitude/longitude for the purpose of data interchange. For all terrain, obstacle or aerodrome mapping data that require a vertical component, the vertical reference must be orthometric height (referenced to MSL) for the purpose of data interchange. Orthometric height can be derived using WGS-84 ellipsoidal heights and an appropriate geoid undulation. Geoid undulation must be derived using the Earth Gravitational Model of 1996 (EGM-96) or its later realizations. If EGM-96 is not used, the geoid model used to derive orthometric height must be provided (See Annex 15, Chapter 3).

When a different temporal reference system is used for some application, the feature catalogue or the metadata associated with the application schema or a data set, as appropriate, must include either a description of the temporal system used or a citation for a document that describes that temporal reference system (see Annex 15, Chapter 3).

1.4.7 Terms, Definitions, and Assumptions

The precise meaning of terms is essential for a clear understanding of spoken or written information. This understanding is critical in areas where safety is of concern. Certain terms and expressions used in this document have specific meanings that must not be misconstrued or applied incorrectly. These terms are defined in a Definitions Chapter.

In addition, the following conventions of requirements documents have been adopted:

- » The term “must” means that compliance is required
- » The term “should” implies that compliance is desirable

Selected tables in this guidance material have been based on ISO style practices. For these tables, column headings indicate the following:

- » Obligation/Condition indicates whether the element is mandatory (M), optional (O), or conditionally required (C)
- » Multiplicity is the number of times an element will appear in the data product (e.g. [0..*])
- » Data Type defines a structured data type
- » Domain is a well-defined set

Unique object identifiers (UIDs) are transient and are internal to both the data provider’s database and to the subsequent receiver’s database. This interchange guidelines does not specify individual feature-based updating mechanisms. Should this be required, it is up to the data interchange implementation to establish unique object identification facilities that can be used for feature-based data updating purposes.

The general format for a numeric value domain notification uses the following pattern: [{d}]{d}, {d}]{d} (e.g. [0.0, 100.0]). The comma leftmost value expresses the minimum inclusive value. The comma rightmost value expresses the maximum inclusive value. The dot leftmost digits express the base of the value. The dot rightmost digits express the mantissa of the value using a precision equal to the number of mantissa digits (e.g. [0.0, 100.0]).

The ISO 19100 series of standards uses two letter prefixes as a way of distinguishing packages that contain a class. The list of ISO prefixes, and their meaning, that have been used within this guidance material include: CI to indicate Citation (ISO 19115); CV to indicate Coverages (ISO 19123); DQ to indicate Data Quality (ISO 19115); EX to indicate Extent (ISO 19115); GM to indicate Geometry (ISO 19107); LI to indicate Lineage (ISO 19115); MD to indicate Metadata (ISO 19115); RS to indicate Reference System (ISO 19115); and TM to indicate Temporal (ISO 19108).

2 Terrain Data

2.1 Scope

This chapter outlines requirements for terrain data. Data originators require the quality characteristics to be defined, including specific numerical values in order to provide terrain data for use in applications. Appendix A provides some illustrative application examples. Certification authorities and data users require information to ensure that terrain data sets satisfy the intended applications. To assist the certification process of an application using obstacle data set(s), certification guidelines are provided in Appendix D.

This document provides the minimum user requirements applicable to the origination and publication of terrain data from creation through the entire life cycle of the data. It provides a minimum list of attributes associated with the terrain data and a description of associated errors that may need to be addressed. Any data processing must be accomplished in accordance with known and established quality processes and procedures.

The terrain data quality requirements in paragraph 2.2 are defined to accommodate the most stringent known application requirements, and not on a basis of acquisition cost. The integrity, accuracy, and resolution requirements specified in this document and the completeness of resulting data sets may not necessarily be sufficient for primary means of navigation.

Land use/land cover database requirements have not been specifically addressed in this document.

2.1.1 Terrain Data Definition

Depending on the source of information, a terrain database may describe something between “bare earth” and “bare earth with cultural features and/or obstacles” (canopy, buildings, etc.).

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

Note: In practical terms, this will represent the continuous surface that exists at the bare earth, the top of the vegetation canopy, or something in-between as presented in Figure 2-1. See paragraphs 2.1.3.17 “Surface Type”, 2.1.3.18 “Recorded Surface”, 2.1.3.19 “Penetration Level” and Appendix B “Remote Sensing Technologies” for further guidance.

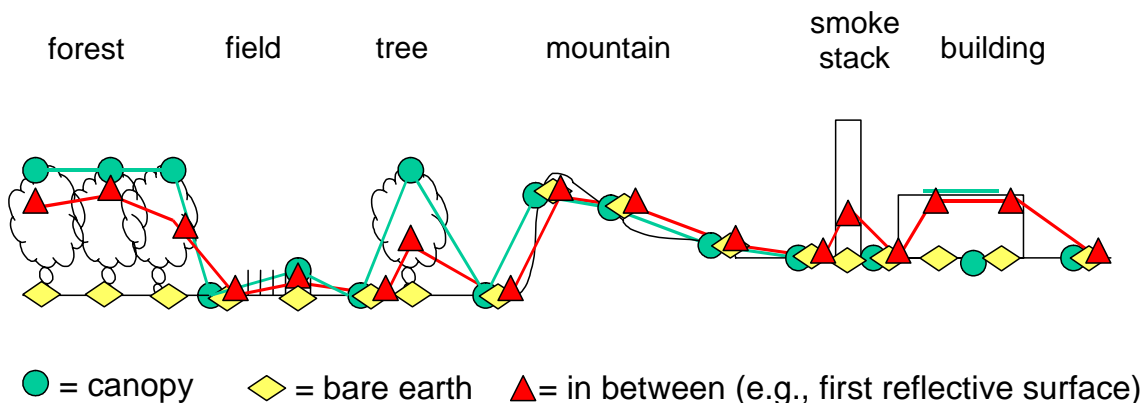


Figure 2-1. Terrain definition

2.1.2 Terrain Data Attributes

This chapter defines a minimum set of attributes for terrain data sets. However, it should be noted that nothing restricts a user from defining or adding new attributes in addition to this minimum set. The data set will also provide historical traceability from origination in accordance with this document.

A terrain database is a digital representation of the vertical extent (elevation) of the terrain at a number of discrete points. Terrain databases are also referred to as digital elevation models (DEMs), digital terrain models (DTMs), and digital surface models (DSMs). Terrain databases consist of a regular or irregular distribution of points. Major features of a terrain database include geometric distribution/position of discrete points, horizontal/vertical datum and specific units of measurement.

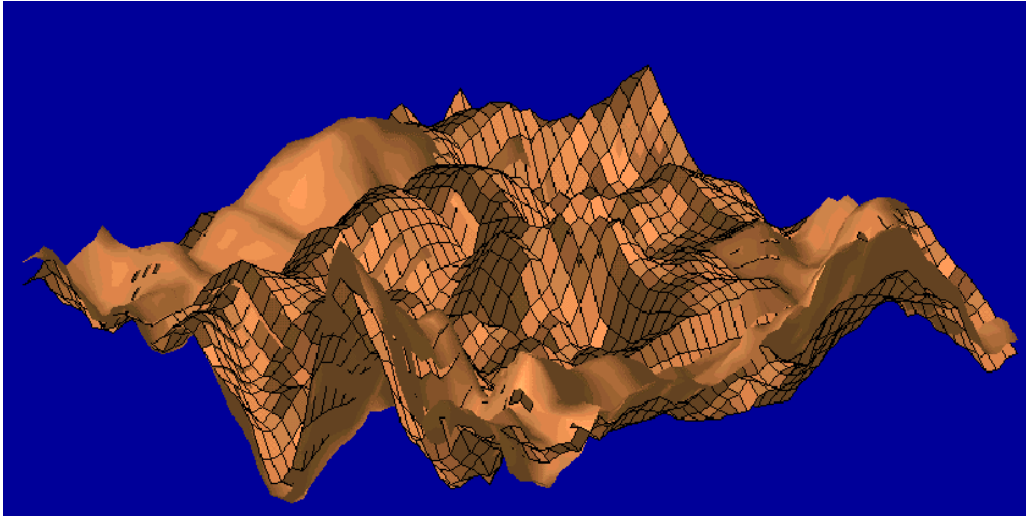


Figure 2-2. Example of a terrain database represented as a DEM

Terrain may be depicted on a grid of elevations at regular intervals. The result is a Digital Elevation model (DEM) represented in Figure 2-2. The diagram of a bare earth model is depicted in Figure 2-3 as a terrain grid of elevations at regular sample points. The vertical extent of the terrain has been stored at regular intervals of latitude and longitude. Obstacles have been shown on the terrain grid; however, in practice, obstacle data would be stored in a separate database.

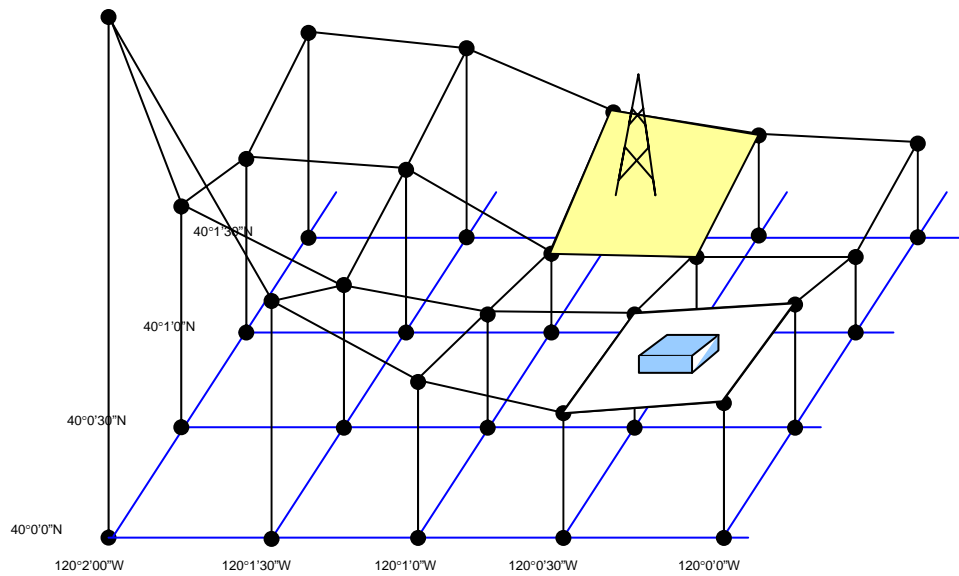


Figure 2-3. DEM of fixed grid elevations annotated with obstacle data

Table 2-1 presents the list of attributes defined to describe terrain data. Attributes that are designated “mandatory” must be recorded. It is recommended that “optional” attributes be recorded as well.

Table 2-1. Terrain Attributes

Attribute	Mandatory/Optional
Area of Coverage	Mandatory
Data Source Identifier	Mandatory
Acquisition Method	Mandatory
Post spacing	Mandatory
Horizontal Reference System	Mandatory
Horizontal Resolution	Mandatory
Horizontal Accuracy	Mandatory
Horizontal Confidence Level	Mandatory
Horizontal Position Data	Mandatory
Elevation	Mandatory
Database Units	Mandatory
Elevation Reference	Mandatory
Vertical Reference System	Mandatory
Vertical Resolution	Mandatory
Vertical Accuracy	Mandatory
Vertical Confidence Level	Mandatory
Surface Type	Mandatory
Recorded Surface	Mandatory
Penetration level	Optional
Known Variations	Optional
Integrity	Mandatory
Date and Time Stamp	Mandatory

2.1.2.1 Area of Coverage

Area of coverage is a descriptor used to identify the boundary of the terrain data. The intent of this attribute is to help the user identify in general terms the area under consideration.

2.1.2.2 Data Source Identifier

Data source identifier uniquely identifies the data originator. Sufficient information must be provided to distinguish among multiple data originators. A permanent record of the originator must be kept to establish an audit trail.

2.1.2.3 Acquisition Method

The acquisition method used to obtain the data must be defined.

Note: This attribute may be used, in conjunction with the surface type, to better understand the measurement properties.

2.1.2.4 Post Spacing

Post spacing is the distance (angular or linear) between two adjacent elevation points. It should be noted that the latitude post spacing might be different from the longitude post spacing.

Terrain database post spacing numerical requirements are presented in both angular and linear units to provide general guidance about the required density of measurement points. The linear measure is an approximation of the angular requirement near the equator. Angular increments may be adjusted when referencing high latitude regions to maintain a constant linear density of measurement points. When linear and angular post-spacing requirements differ, the linear requirement must take precedence.

2.1.2.5 Horizontal Reference System

The horizontal reference system is the datum to which the positions of the elevations are referenced. SARPs require that coordinates used for air navigation must be expressed in the WGS-84 reference system. If the horizontal reference system is not WGS-84, the reference system and transformation parameters to WGS-84 must be specified. (see Chapter 1)

2.1.2.6 Horizontal Resolution

Horizontal resolution can have two components:

The units used in the measurements. Position recorded in one-arc second increments has a higher resolution than that taken in one-arc minute increments.

The number of decimal places for the recording of the position. Use of more decimal places can provide for higher resolution.

It is important to note that resolution and post spacing are not synonymous and can be confused with each other (see Definitions).

2.1.2.7 Horizontal Accuracy

Accuracy is the degree of conformance between the estimated or measured value and the true value. For measured positional data the accuracy is normally expressed in terms of a distance from a stated position within which there is a defined confidence of the true position falling.

Horizontal accuracy must be stated in the same units as used for the elevation. The statistical derivation of the horizontal accuracy must be stated. Bias and standard deviation should be provided. (For further details see Appendix C.)

2.1.2.8 Horizontal Confidence Level

The confidence level is the probability that errors in a database are within the limits specified (see Definitions and Appendix C). The confidence level of the position must be stated, e.g. as a percentage.

2.1.2.9 Horizontal Position Data

Horizontal position data are defined by geodetic latitude and longitude. The geodetic latitude of a point is defined as the angle between the normal to the ellipsoid at that point, and the equatorial plane. The geodetic longitude of a point is the angle between its geodetic meridian plane and the IRM (IERS Reference Meridian). However, it is recognized that some terrain databases use projection-based coordinates (e.g. Universal Transverse Mercator (UTM) Eastings and Northings). These terrain databases must include a projection type attribute.

Latitude - The format for latitude, the north-south component of position, must be expressed, e.g. degree, minutes, seconds or decimal degrees.

Longitude - The format for longitude, the east-west component of position, must be expressed, e.g. degree, minutes, seconds or decimal degrees.

2.1.2.10 Elevation

Elevation is the vertical distance of a point or a level, on or affixed to the surface of the Earth measured from mean sea level. Elevation must be expressed in linear units that are consistent with the accuracy and resolution specifications.

2.1.2.11 Database Units

For every attribute that requires it, the units used must be stated and the units must be consistent within the database.

2.1.2.12 Elevation Reference

The elevation reference corresponds to the method used to determine the elevation value recorded for each cell of the data set. The elevation reference must be explicitly defined.

Considerations about elevation reference include the following:

- The provided values may correspond to a particular corner or the centre of a DEM cell, the mean elevation value of the cell, the maximum elevation value, etc;
- In a regularly distributed grid (i.e., square, rectangular) the first data point of the set is the reference point with a known recorded planimetric position, to which the other data points are referenced;

When the data represent the terrain elevation at specific latitude/longitude points, then the terrain elevation between the database sample points may be higher or lower than the database values.

2.1.2.13 Vertical Reference System

The vertical reference system is the datum to which the elevation values are referenced. Mean Sea Level (MSL) is the required vertical reference system. The Earth Gravitational Model (EGM-96) must be used as the global gravity model. If 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 must be provided (see Chapter 1).

2.1.2.14 Vertical Resolution

Vertical resolution may have two components:

- The units used in the measurements. For example, elevation recorded in one-foot increments has a higher resolution than that taken in one-meter increments;
- The number of decimal places for the recording of the elevation. Use of more decimal places can provide for higher resolution.

2.1.2.15 Vertical Accuracy

Accuracy is the degree of conformance between the estimated or measured value and the true value. For measured positional data the accuracy is normally expressed in terms of a distance from a stated position within which there is a defined confidence of the true position falling. Vertical accuracy must be stated in the same units as used for the elevation. The statistical derivation of the vertical accuracy must be stated. Bias and standard deviation should be provided. (For further details see Appendix C.)

2.1.2.16 Vertical Confidence Level

The confidence level is the probability that errors in a database are within the limits specified (see Definitions and Appendix C).

The confidence level of the elevation must be stated, e.g. as a percentage.

2.1.2.17 Surface Type

Surface type is a classification of the recorded surface, e.g., marshland, water, permanent ice, etc.

2.1.2.18 Recorded Surface

Recorded surface identifies the surface that the elevation data represent. Some examples of surfaces that may be recorded by available technologies are:

- The ***bare earth*** recorded by land survey or by remote sensing techniques when vegetation or snow/ice is not present.
- The ***reflective surface*** recorded by either an active or a passive remote sensing sensor.

The sensor equipment manufacturer or the service provider must identify the surface that has been recorded.

2.1.2.19 Penetration level

The Recorded Surface attribute identifies the surface the elevation data represent. When the position of this surface, between the bare earth and top of the canopy or the surface of snow or ice is known, it should be recorded in the attribute “Penetration Level”. Nevertheless, when recorded by either active or passive remote sensors, it is recognized that the degree of penetration of the sensor signal is frequently impossible to determine precisely. The estimated penetration will be expressed as a unit of measurement e.g. meters or feet.

Note: For the purpose of this document, it is important to understand the impact of sensor penetration on the accuracy of recorded values. Photographic cameras that record information from every reflective object are one example of a passive sensor. Active sensors radiate energy and the reflected energy that returns to the sensor is used to determine heights. Some sensors detect reflected energy from the top of the forest canopy or ice surface and others will collect reflected energy which has penetrated to bare terrain or somewhere in between. The actual or estimated penetration level, if known, is to be recorded in the attribute “Penetration Level”.

2.1.2.20 Known Variations

Known variations specify predictable changes to the data e.g., seasonal elevation changes due to snow accumulations or vegetation growth.

2.1.2.21 Integrity

Integrity of data is the degree of assurance that the data and its value have not been lost nor altered since the data origination or authorized amendment. The integrity of the data set must be expressed, indicating the probability of any single data element having been changed inadvertently since the creation of the data set.

2.1.2.22 Date and Time Stamps

Time stamps are information about the origination or modification date and time of the data. Time stamps must refer to Universal Coordinated Time (UTC) and date stamps must refer to the Gregorian calendar.

2.2 Terrain Data Quality Requirements

2.2.1 Introduction

Terrain data quality requirements have been defined so to accommodate the most stringent known application requirements. It is recognized that some current applications have less demanding requirements and that enhanced capabilities or services may be provided with data of a better quality. Future applications may necessitate additional requirements.

The integrity, accuracy, and resolution requirements specified in this document and the completeness of resulting databases are not necessarily sufficient for primary means of navigation. The numerical values shown are not to be construed as system level or application specific requirements. System level or application specific requirements are dependent on a safety analysis of the entire system, of which the database is only one part. The following are examples of the applications that use obstacle and/or terrain data:

- Ground Proximity Warning System (GPWS) with forward looking terrain avoidance function
- Minimum Safe Altitude Warning (MSAW) system
- Determination of contingency procedures for use in the event of an emergency during a missed approach or take-off
- Aircraft operating limitations analysis
- Instrument Procedure Design (including circling procedure)
- Determination of en-route “drift down” procedures and en-route emergency landing location
- Advanced Surface Movement Guidance and Control System (A-SMGCS)
- Aeronautical chart production and on-board databases
- Flight simulator
- Synthetic Vision and

- Aerodrome/heliport obstacle restriction and removal

All the above applications with the exception of A-SMGCS and aeronautical charting are detailed in Appendix A.

2.2.2 Areas of Coverage

The requirements for terrain data quality (accuracy, integrity and resolution) are provided for the following areas:

- Area 1: entire territory of a State
- Area 2: terminal control area
- Area 3: aerodrome/heliport area
- Area 4: Category II or III operations area

2.2.2.1 Area 1 – The State

Area 1 covers the entire state territory including terminal control area and aerodromes/heliports. The numerical requirements for terrain in Area 1 were derived from existing SARP for en-route terrain adjusted to reflect digital needs and the understanding that they could be supported by present and anticipated surveying techniques.

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

Table 2-2. Terrain data quality requirements for Area 1 – the State

Quality attributes	Area 1 — the State
Horizontal Accuracy	50.0 m
Data Integrity	Routine (10^{-3})
Vertical Accuracy	30.0 m
Vertical Resolution	1.0 m
Confidence Level	90%
Post Spacing	3 arc second (approx. 90 m)

2.2.2.2 Area 2 – Terminal Control Area

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 2 Terrain

Within an area covered by a 10 km radius from the ARP, terrain data must be collected in accordance with the Area 2 numerical requirements listed in Table 2-3.

In the area between 10 km and the TMA boundary or 45 km radius (whichever is smaller), terrain that penetrates the horizontal plane 120 m above the lowest runway elevation must be collected and recorded in accordance with the Area 2 numerical requirements listed in Table 2-3.

In the area between 10 km and the TMA boundary or 45 km radius (whichever is smaller), terrain that does not penetrate the horizontal plane 120 m above the lowest runway elevation must be collected and recorded in accordance with the Area 1 numerical requirements listed in Table 2-2.

In those portions of Area 2 where the flight operations are prohibited due to very high terrain or other regulations, terrain must only be collected and recorded in accordance with the Area 1 numerical requirements listed in Table 2-2.

Table 2-3. Terrain data quality requirements for Area 2 — Terminal Airspace

Quality attributes	Area 2 — Terminal Airspace
Horizontal Accuracy	5.0 m
Data Integrity	Essential (10^{-5})
Vertical Accuracy	3.0 m
Vertical Resolution	0.1 m
Confidence Level (1σ)	90%
Post Spacing	1.0 arc second (30 m)

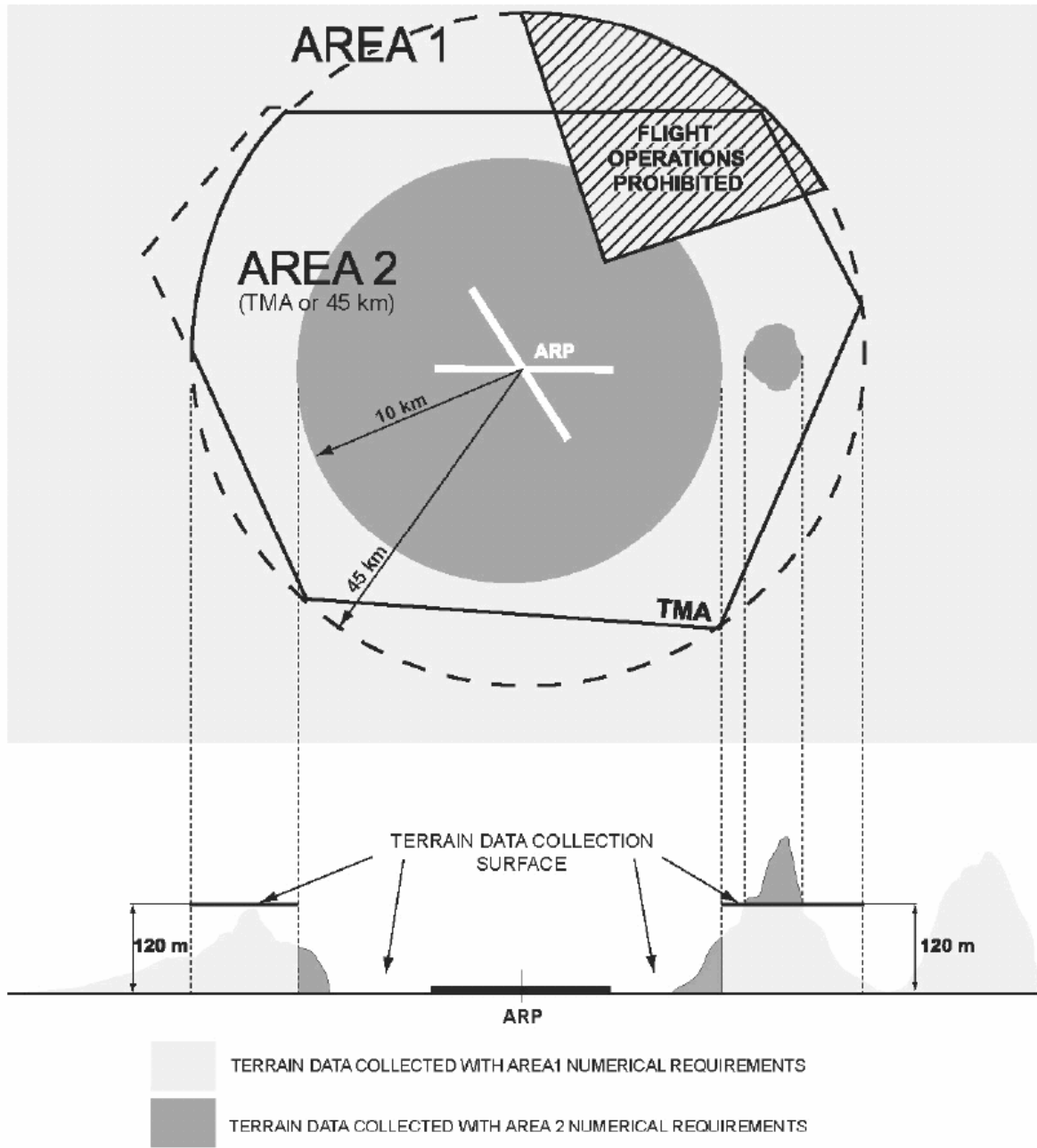


Figure 2-4. Areas 1 and 2 for terrain

2.2.2.3 Area 3 — Aerodrome/Heliport Area

Aerodrome mapping is addressed in Chapter 4 which establishes requirements for aerodrome databases. This chapter describes the area and the terrain data numerical requirements for digital terrain data supporting applications described in Chapter 4.

2.2.2.4 Supplemental Terrain Requirements for Aerodrome Mapping

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 2-5).

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.

Numerical quality requirements for terrain data in the aerodrome mapping area are listed in Table 2-4.

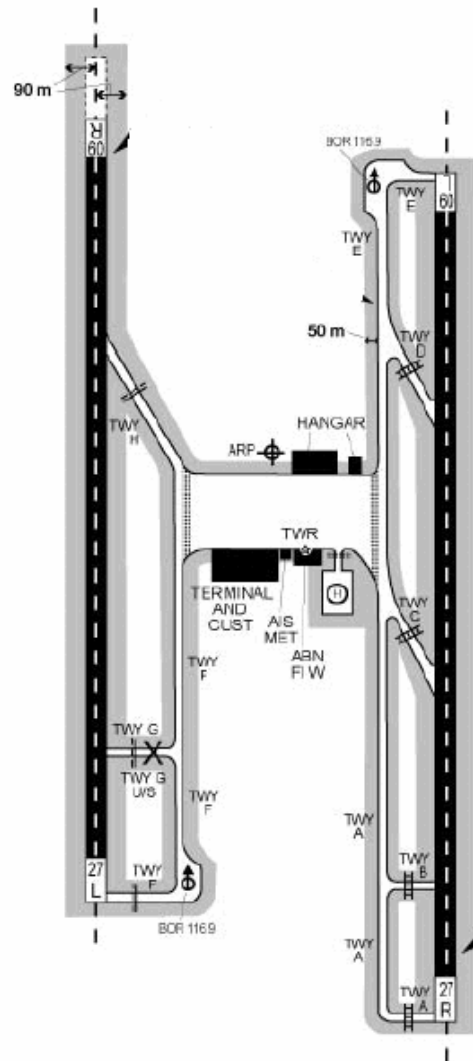


Figure 2-5. Exclusion of interior region for aerodrome mapping

Table 2-4 Terrain data quality requirements for Area 3 — Aerodrome Mapping

Quality attributes	Area 3 — Aerodrome Mapping
Horizontal Accuracy	0.5 m
Data Integrity	Essential (10^{-5})
Vertical Accuracy	0.5 m
Vertical Resolution	0.01 m
Confidence Level (1σ)	90%
Post Spacing	0.6 arc second (20 m)

2.2.2.5 Area 4 — CAT II and III Operation Area

Area 4 is defined as the radar altimeter area for CAT II/III precision approach procedures. The area extends from the runway threshold to 900 m (3000 ft) from the threshold. It is 120 m (400 ft) wide and centred on an extension of the runway centreline.

At those airports where runways are equipped for CAT II or III operations, terrain data requirements for Area 4, provided in Table 2-5, must apply.

Table 2-5. Terrain data quality requirements for Area 4 — CAT II/III Operations Area

Quality attributes	Area 4 — CAT II/III Operation Area
Horizontal Accuracy	2.5 m
Data Integrity	Essential (10^{-5})
Vertical Accuracy	1.0 m
Vertical Resolution	0.1 m
Confidence Level (1σ)	90%
Terrain Publication Timeliness	As required
Post Spacing	0.3 arc second (9 m)

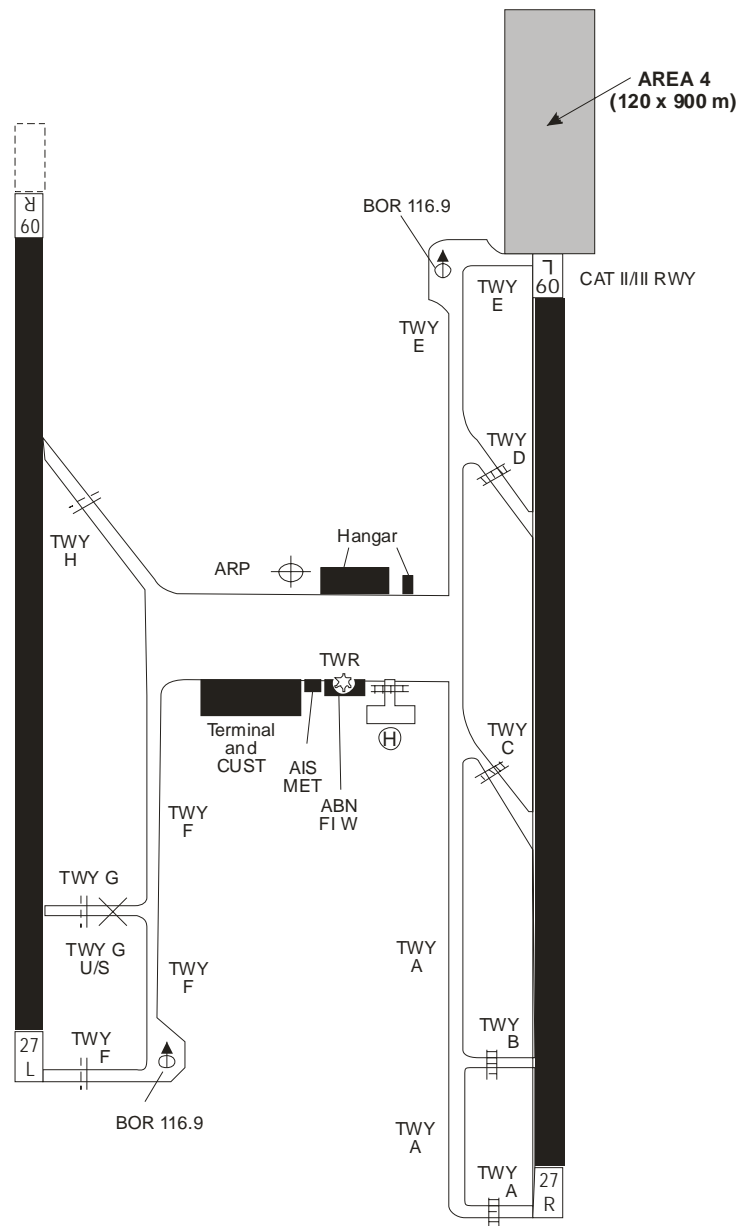


Figure 2-6. Terrain data collection surface — Area 4

Table 2-6. Summary of terrain data quality requirements

Quality Attributes	Area 1 The State	Area 2 Terminal Control Area	Area 3 Aerodrome/ Heliport Area	Area 4 CAT II/III Operations Area
Horizontal Accuracy	50.0 m	5.0 m	0.5 m	2.5 m
Data Integrity	Routine (10^{-3})	Essential (10^{-5})	Essential (10^{-5})	Essential (10^{-5})
Vertical Accuracy	30.0 m	3.0 m	0.5 m	1.0 m
Vertical Resolution	1.0 m	0.1 m	0.01 m	0.1 m
Confidence Level (1σ)	90%	90%	90%	90%
Post Spacing	3 arc second (approx. 90 m)	1.0 arc second (approx. 30 m)	0.6 arc second (approx. 20 m)	0.3 arc second (approx. 9 m)
Maintenance Period	as required	as required	as required	as required

2.3 Data Product Specification

2.3.1 Overview

A terrain database is a digital representation of the vertical extent (elevation) of the terrain at a number of discrete points. Terrain databases are also referred to as digital elevation models (DEMs), digital terrain models (DTMs), and digital surface models (DSMs) (Figure 2-3). Terrain databases may consist of a regular or irregular distribution of points.

According to Annex 15 and this guidance material, terrain is defined as “the natural surface of the earth excluding obstacles”. In practical terms, this will represent the continuous surface that exists at the bare earth, the top of the vegetation canopy, or something in between (Figure 2-1).

2.3.2 Specification Scopes

A terrain data product may not be homogeneous across the whole geographic area of the product, but may consist of subsets. For each such subset, the scope must be identified. For example, each subset may be defined by:

extent - a subset may be identified by spatial, vertical, or temporal extent within the entire data product

Example: This product contains continuous elevation models centred on the Reno International Airport area that comply with Area 1 and Area 2.

attributes - a subset may be identified by values of a set of common attributes in the data product

Example: Area 1 terrain is represented by a DEM with three arc-second post spacing. Area 2 is represented by a DEM with one arc-second post spacing.

coverage - a subset may be identified by a set of coverages within the data product

Example: This product contains two continuous bald earth elevation models centred on the Reno International Airport and complies with coverage for Area 1 and Area 2.

Requirements for identifying the specification scope for terrain data products are listed in Table 2-7, while the UML model is given in Figure 2-7.

Table 2-7. Identification of specification scopes for terrain data

Item Name	Definition	Obligation/ Condition	Multi.	Data Type	Domain
Scope identification	Identification of the scope for the purpose of a particular data specification	M	1	Character String	Free text
Level	hierarchical level of the data specified by the scope	O	1	Class	MD_Scope Code <<codeList>>
levelName	name of the hierarchy level of the data specified by the scope	O	1	Character String	Free text
Extent	information about the spatial, vertical and temporal extent of the data specified by the scope	O	1	Class	EX_Extent
levelDescription	detailed description about the level of the data specified by the scope	O	N	Character String	Free text
Coverage	coverages to which the information applies	O	N	Character String	Free text

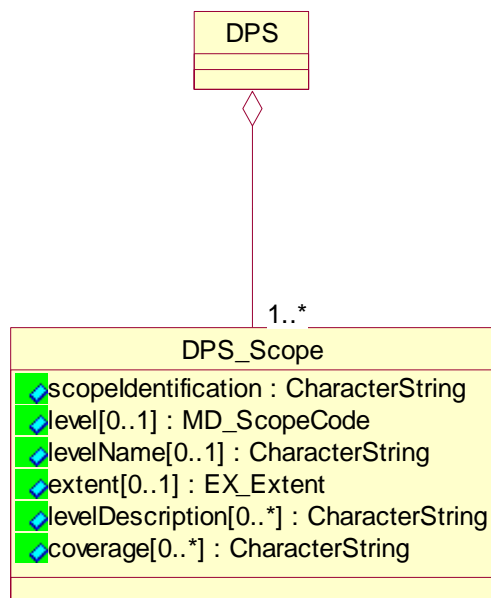


Figure 2-7. UML model for scope information for terrain data

2.3.3 Data Product Identification

Requirements for identifying terrain data products are listed in Table 2-8, while the UML model is given in Figure 2-8. The mandatory items listed in Table 2-8 are described below.

title - the title of the data product

Example: Digital Elevation Models for the Reno International Airport (KRNO) terminal area.

abstract - a brief narrative summary of the content of the data product

Example: Included within this product are two continuous bald earth elevation models that have been derived from the USGS National Elevation Data set.

topic category - the main theme(s) of the data product

Example: MD_TopicCategoryCode 006 – elevation.

geographic description - description of the geographic area covered by the data product

Example: The Area 2 terrain model product subset covers a polygon area measuring 24.3 NM (45 km) by 24.3 NM (45 km) centred on the Reno International Airport.

Table 2-8. Identification information for terrain data

Item Name	Definition	Obligation/ Condition	Multi.	Data Type	Domain
Title	title of data product	M	1	Character String	Free text
alternateTitle	other name by which the data product is known	O	N	Character String	Free text
Abstract	brief narrative summary of the content of the data product	M	1	Character String	Free text
Purpose	summary of the intentions with which the data product is developed	O	1	Character String	Free text
TopicCategory	main theme(s) of the data set	M	N	Class	MD_TopicCategoryCode <<CodeList>>
spatialRepresentationType	form of spatial representation	O	N	Class	MD_SpatialRepresentationTypeCode
spatialResolution	factor which provides a general understanding of the density of spatial data in the data set	O	N	Class	MD_Resolution <<Union>>
geographicDescription	description of the geographic area within which data is available	M	N	Class	EX_GeographicDescription
supplementalInformation	any other descriptive information about the data set	O	1	Character String	Free text

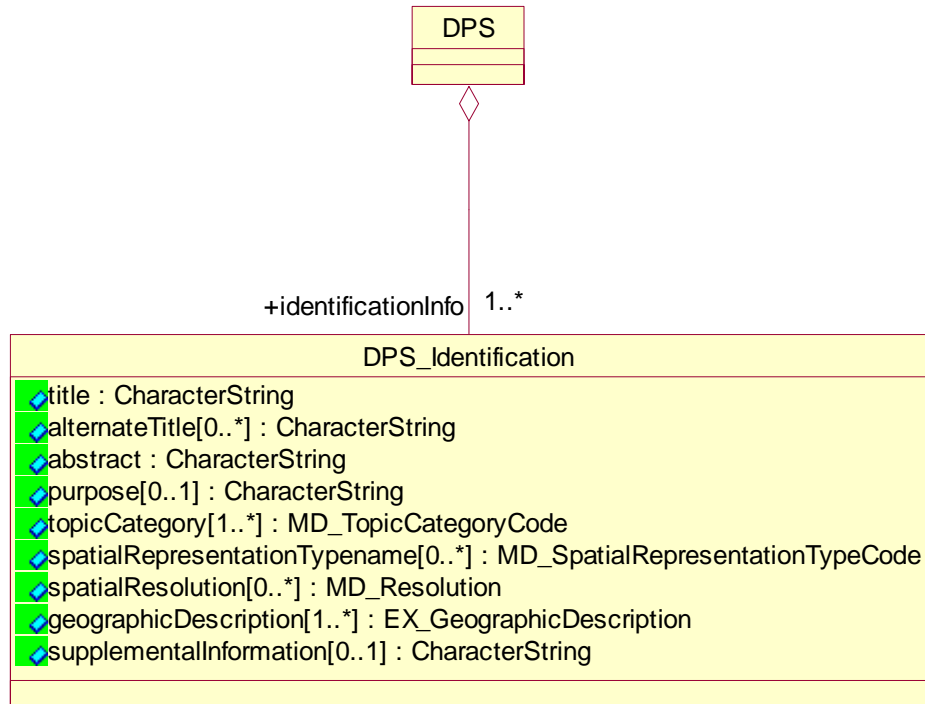


Figure 2-8. UML model for terrain data identification information

2.3.4 Data Content and Structure

Terrain data sets are coverages. A coverage is considered a subtype of a feature and can be derived from a collection of terrain features that have common attributes/properties. Range describes coverage within a spatio-temporal domain. A range is a set of attribute values. A spatio-temporal domain is a set of geometric objects described in terms of direct positions within a bounded space that correspond to the extent of the coverage. Examples of content information for a data product can be found in ISO 19123. For the purpose of a terrain DPS, the following elements must be identified to describe coverage:

Coverage ID – uniquely identifies the area covered by the data set

Example: KRNO_Area2

Coverage description – technical description of the coverage

Example: Area 2 is the terminal airspace 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.

Coverage type - the geometry model used for this coverage. It must mention the dimension and the interpolation type when appropriate.

Example: continuous coverage

Specification (role name) – additional coverage information.

Example: In selected geographic areas, due to the close proximity of an aerodrome, the extent of the terrain coverage that is controlled by aerodrome authorities may vary with time of day and traffic density.

Requirements for identifying coverage of terrain data products are listed in Table 2-9, while the UML model is given in Figure 2-9.

Table 2-9. Coverage identification for terrain data

Item Name	Definition	Obligation/Condition	Multi.	Data Type	Domain
Coverage ID	unique identifier of coverage	M	1	CharacterString	free text
Coverage Description	technical descr. of the coverage	M	1	CharacterString	free text
Coverage Type	type of coverage	M	1	CharacterString	free text
Specification (role name)	additional coverage information	M	1	Class	CV_Coverage

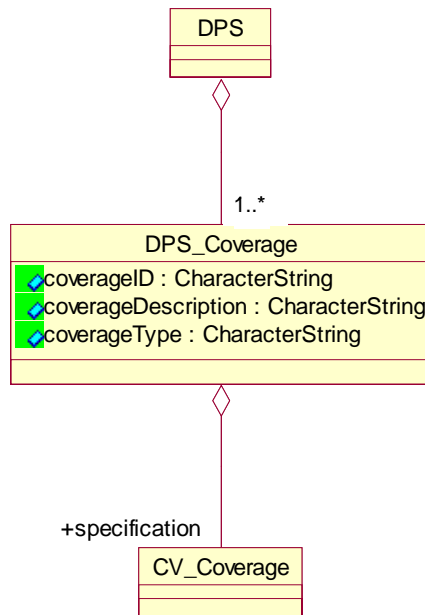


Figure 2-9. UML model for terrain data coverage

The model integration diagram (Figure 2-10) shows the dependencies between the terrain application schema and other ISO packages.

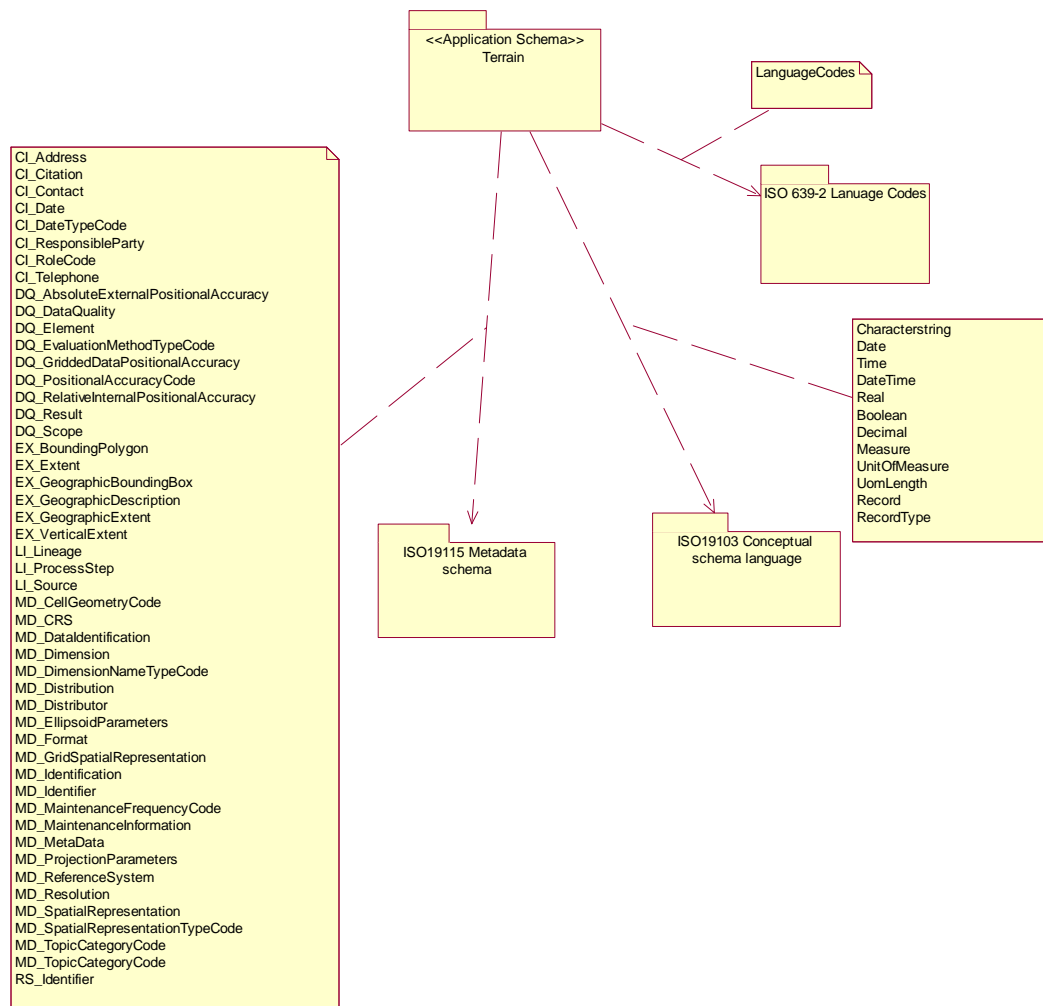


Figure 2-10. Model integration diagram for terrain data

The application schema for terrain data consists of one top-level package containing the terrain metadata types (Figure 2-11).

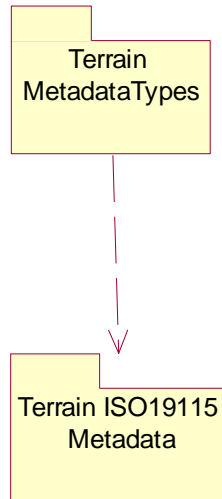


Figure 2-11. Application schema for terrain data

2.3.5 Reference Systems

The DPS must include information that defines the reference systems used in the data product. This must include the spatial reference system and the temporal reference system.

The spatial reference systems used must be a coordinate reference system as defined in ISO 19111. A coordinate reference system allows for the definition of horizontal and vertical datums. In accordance with Annex 15, the horizontal datum is WGS-84, and the vertical datum is MSL using appropriate geoid model such as EGM-96. The temporal reference system allows for the terrain to be effective starting at a point in time until superseded. The Gregorian calendar and Coordinated Universal Time (UTC) must be used as the temporal reference system for terrain data products complying with this standard.

Example: Horizontal positions are provided as latitude/longitude coordinates in decimal degrees (WGS-84); vertical values are provided in meters with respect to EGM-96. Time and date values are provided with respect to UTC and the Gregorian calendar.

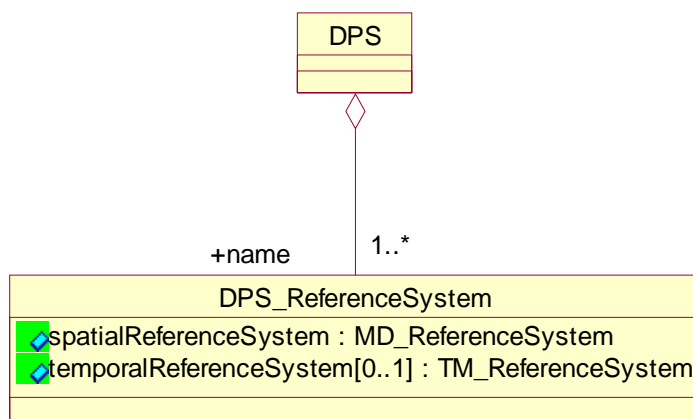
Reference system identifiers must identify the reference systems. These may take the form of either:

- the names of the reference systems (e.g. WGS-84), or
- codes for the reference systems, and a statement of the source of those codes (e.g. code EPSG::4326 for WGS-84 [European Petroleum Survey Group], code WGE for WGS-84 [National Geospatial-Intelligence Agency and ARINC-424])

Requirements for identifying the reference system for terrain data products are listed in Table 2-10, while the UML model is given in Figure 2-12.

Table 2-10. Reference system identification for terrain data

Item Name	Definition	Obligation/Condition	Multi.	Data Type	Domain
spatialReferenceSystem	identifier of spatial reference system	M	1	Class	MD_ReferenceSystem
temporalReferenceSystem	identifier of temporal reference system	O	1	Class	TM_ReferenceSystem

**Figure 2-12. UML model for reference system information for terrain data**

2.3.6 Data Quality

Information about the quality of available terrain data sets is vital to the process of selecting a data set in that the value of data is directly related to its quality. For the purpose of evaluating the quality of a data set, clearly defined procedures must be used in a consistent manner. Complete descriptions of the quality of a data set will encourage the sharing, interchange and use of appropriate geographic data sets. This enables data producers to express how well their product meets the criteria set forth in its product specification and data users to establish the extent to which a data set meets their requirements.

For terrain data, Chapter 2.2 provides a set of quality parameters. These include:

Horizontal accuracy

Horizontal resolution

Horizontal confidence level

Vertical accuracy

Vertical resolution

Vertical confidence level

- » Data source identifier
- » Data integrity
- » Time stamp

Note that Chapter 2.2 specifies quality requirements and considerations for terrain within 50 meters of the aerodrome movement area, within the CAT II and III operations area (Area 3), within the terminal airspace (Area 2), and the worldwide (Area 1).

Data files must be protected by CRC (see Annex 15) to ensure that data is not corrupted during the interchange process. Each manufacturer, or customer, in the distribution chain is responsible for verifying that data is wrapped and received using a CRC.

Requirements for identifying the quality of terrain data products are listed in Table 2-11, while the UML model is given in Figure 2-13. For a more general discussion about quality conformance and reporting, refer to Appendix C of this document.

Table 2-11. Quality identification for terrain data

Item Name	Definition	Obligation/Condition	Multi.	Data Type	Domain
dataQuality	quality information concerning the data product	M	N	Class	DQ_DataQuality

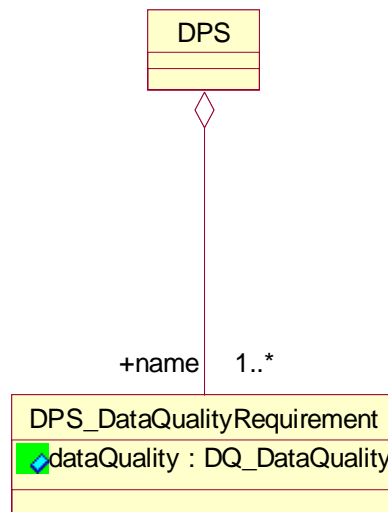


Figure 2-13. UML model for quality information for terrain data

2.3.7 Data Capture

The scope of this data interchange standard does not include the process of data capture, although it is recognized that the content and the quality of a terrain data product is significantly correlated with the data capture process. Guidance for terrain data capture is provided in Appendix B.

This DPS defines attributes and metadata that enable the results of the terrain data capture methods to be communicated. In addition, the way in which data concerning real-world geo-spatial phenomena and their characteristics are captured must be specified. The data to be included in this Chapter of the DPS must include a statement that must be a general description of the process for the capture of the data.

Conformance quality levels may need to be provided for intermediate data, which may be required for the data production. Requirements for identifying the data capture method for terrain data products are listed in Table 2-12, while the UML model is given in Figure 2-14.

Table 2-12. Data capture identification for terrain data

Item Name	Definition	Obligation/Condition	Multi.	Data Type	Domain
dataCaptureStatement	general description of the process for the capture of the data	M	1	CharacterString	Free text

Example: The USGS has compiled the National Elevation Data set for public mapping and modeling use in a variety of applications, aviation safety being one of these applications. Terrain data was originally created from cartographic and aerial photo source materials. Terrain data coordinates have been converted from the North American Datum 1983 (NAD-83) to the WGS-84, then merged, re-sampled, quality controlled and formatted into USGS DEM format for delivery.

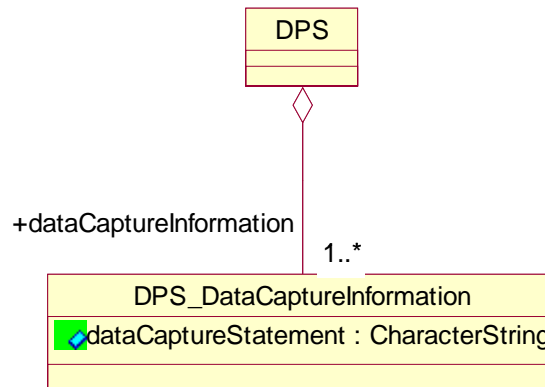


Figure 2-14. UML model for terrain data capture information

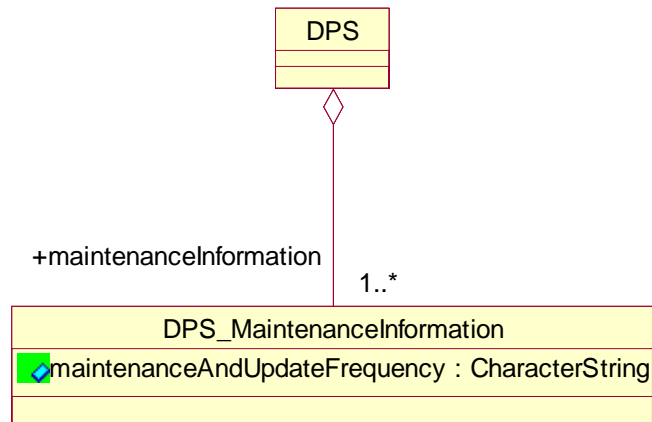
2.3.8 Data Maintenance

Terrain data sets are increasingly being used in dynamic environments: shared, interchanged, and used for purposes that require both accuracy and temporal relevance. Continuous maintenance and timely updates of terrain databases are vital to the process of end-user applications. Requirements for identifying the maintenance method for terrain data products are listed in Table 2-13, while the UML model is given in Figure 2-15. For a more general discussion about maintenance, refer to Appendix D of this document.

Table 2-13. Maintenance identification for terrain data

Item Name	Definition	Obligation/Condition	Multi.	Data Type	Domain
maintenance and update frequency	Frequency with which changes and additions are made to the product	M	1	Class	MD_MaintenanceFrequencyCode <<CodeList>>

Example: MD_MaintenanceFrequencyCode 010 reflects an irregular update cycle.

**Figure 2-15. UML model for maintenance information for terrain data**

2.3.9 Portrayal

The terrain DPS may provide information on how the data is to be presented as graphical output. If portrayal information is provided, applicable requirements are given in Table 2-14, while the UML model is given in Figure 2-16.

Table 2-14. Portrayal information for terrain data

Item Name	Definition	Obligation/Condition	Multi.	Data Type	Domain
portrayalCatalogueCitation	Bibliographic reference to the portrayal catalogue	C/if provided	N	Class	CI_Citation

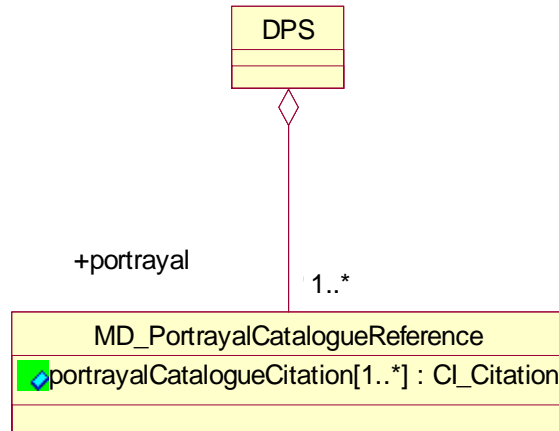


Figure 2-16. UML model for portrayal information for terrain data

2.3.10 Data Product Delivery

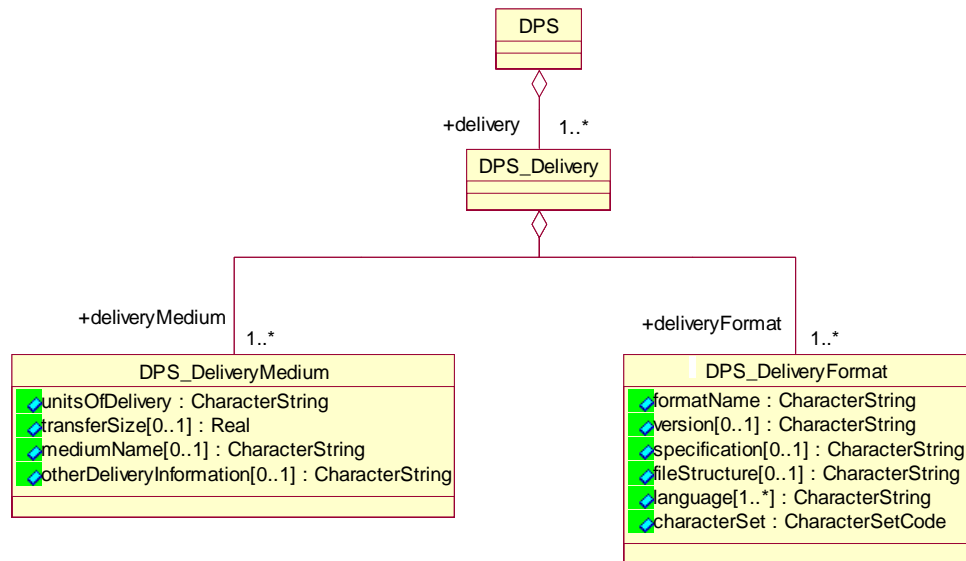
This DPS contains no specific requirements for data product delivery, however, a compliant physical implementation of the DPS should identify the following elements: format name, version, specification, file structure, language, character set, units of delivery, transfer size, medium name, and other delivery information. If data product delivery information is provided, applicable requirements are given in Tables 2-15 and 2-16, while the UML model is given in Figure 2-17.

Table 2-15. Delivery format information for terrain data

Item Name	Definition	Obligation/Condition	Multi.	Data Type	Domain
formatName	name of the data format	M	1	Character String	Free text
version	version of the format (date, number, etc)	O	1	Character String	Free text
specification	name of a subset, profile, or product specification of the format	O	1	Character String	Free text
fileStructure	structure of delivery file	O	1	Character String	Free text
language	language(s) used within the data set	M	N	Character String	ISO 639-2, other parts may be used
characterSet	full name of the character coding standard used for the data set	O	1	Class	MD_CharacterSetCode

Table 2-16. Delivery medium information for terrain data

Item Name	Definition	Obligation/Condition	Multi.	Data Type	Domain
unitsOfDelivery	description of the units of delivery (e.g. tiles, layers, geographic areas)	M	1	Character String	Free text
transferSize	estimated size of a unit in the specified format, expressed in Mbytes	O	1	Real	>0
mediumName	name of the data medium	O	1	Character String	Free text
otherDeliveryInformation	other information about the delivery	O	1	Character String	Free text

**Figure 2-17. UML model for delivery information for terrain data**

2.3.11 Additional Information

This Chapter of the DPS may include any other aspects of the data product not provided elsewhere in the specification.

2.3.12 Metadata

The metadata requirements for terrain data products are derived from ISO 19115. Metadata is classified as identification information, quality information, maintenance information, spatial representation information, reference system information, distribution information, extent information, and citation information. The UML models for the required metadata are given in Figures 2-18 through 2-26. Descriptions of metadata elements and code lists are given in Appendices F and G, respectively.

Figure 2-18 defines the class MD_MetaData, which is a composition of all the metadata entities that are required to support the interchange of terrain data products.

Note. - the following attributes are not part of ISO 19115, but are required by this interchange standard: *acqMethod*, *horzUnit*, *vertUnit*, *recdSurf*, *penetrationLevel*, *integrity*, and *surfType*.

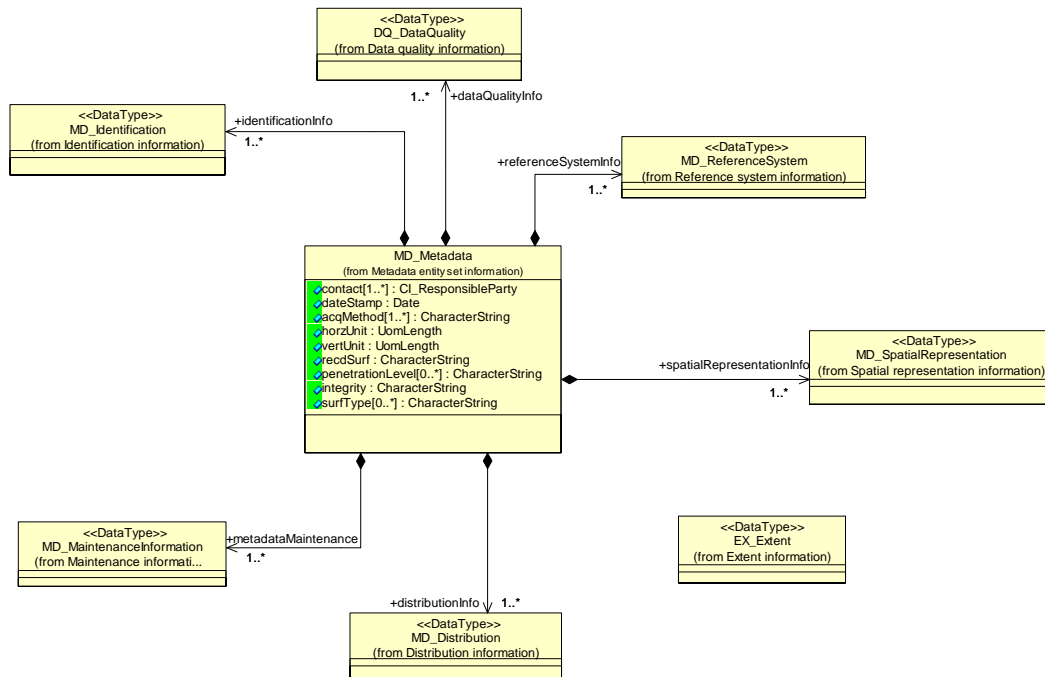


Figure 2-18. Terrain metadata – overview

Figure 2-19 defines the metadata classes required to identify terrain data.

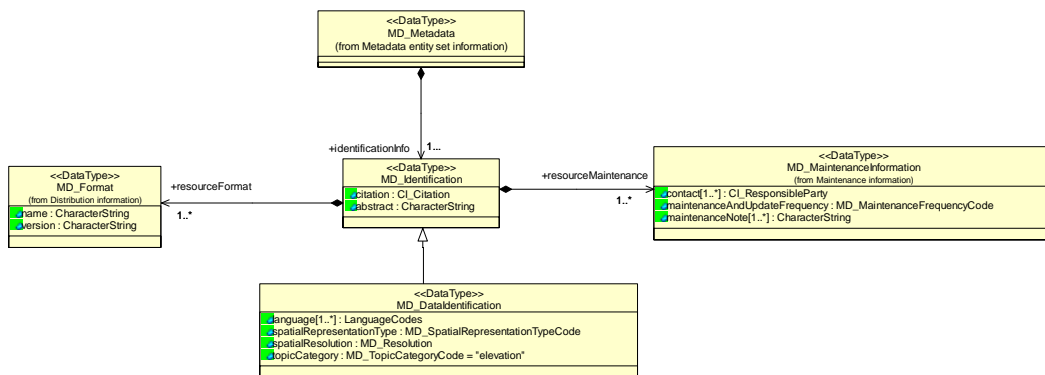


Figure 2-19. Terrain metadata – identification

Figure 2-20 defines the metadata required to give an assessment of the quality and provide lineage information for terrain data.

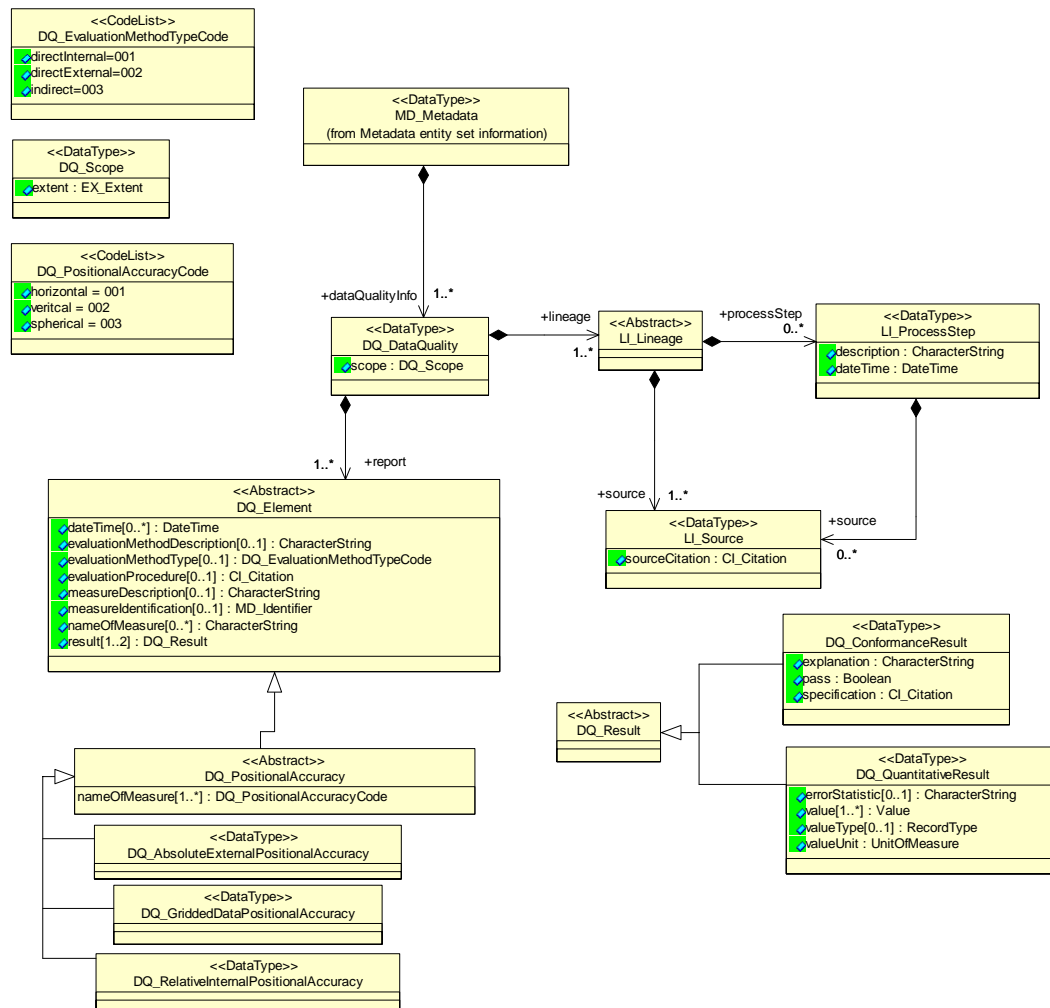


Figure 2-20. Terrain metadata – quality

Figure 2-21 defines the metadata required to describe the maintenance and update practices for terrain data.

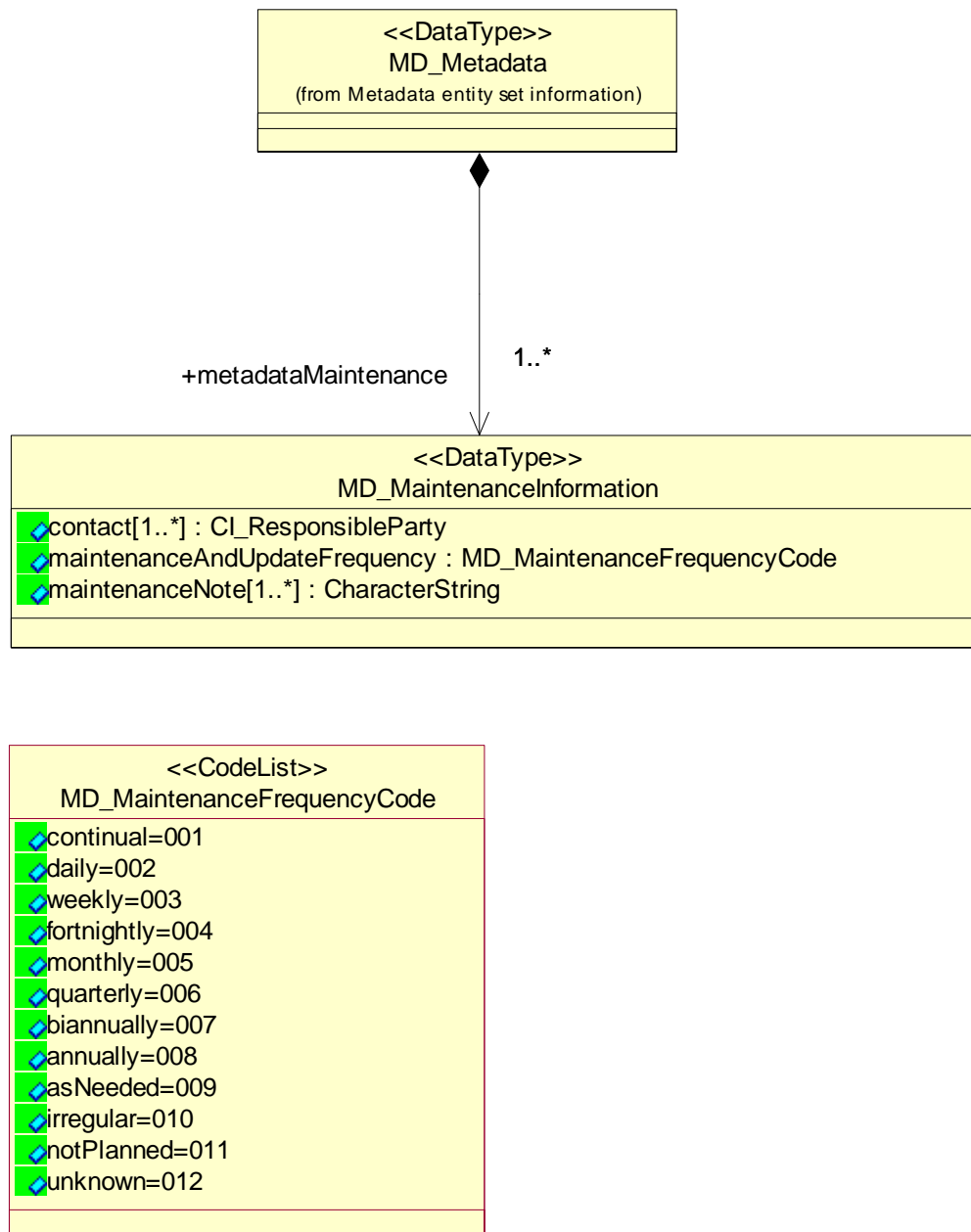


Figure 2-21. Terrain metadata – maintenance

Figure 2-22 defines metadata required to describe the mechanism used to represent terrain information.

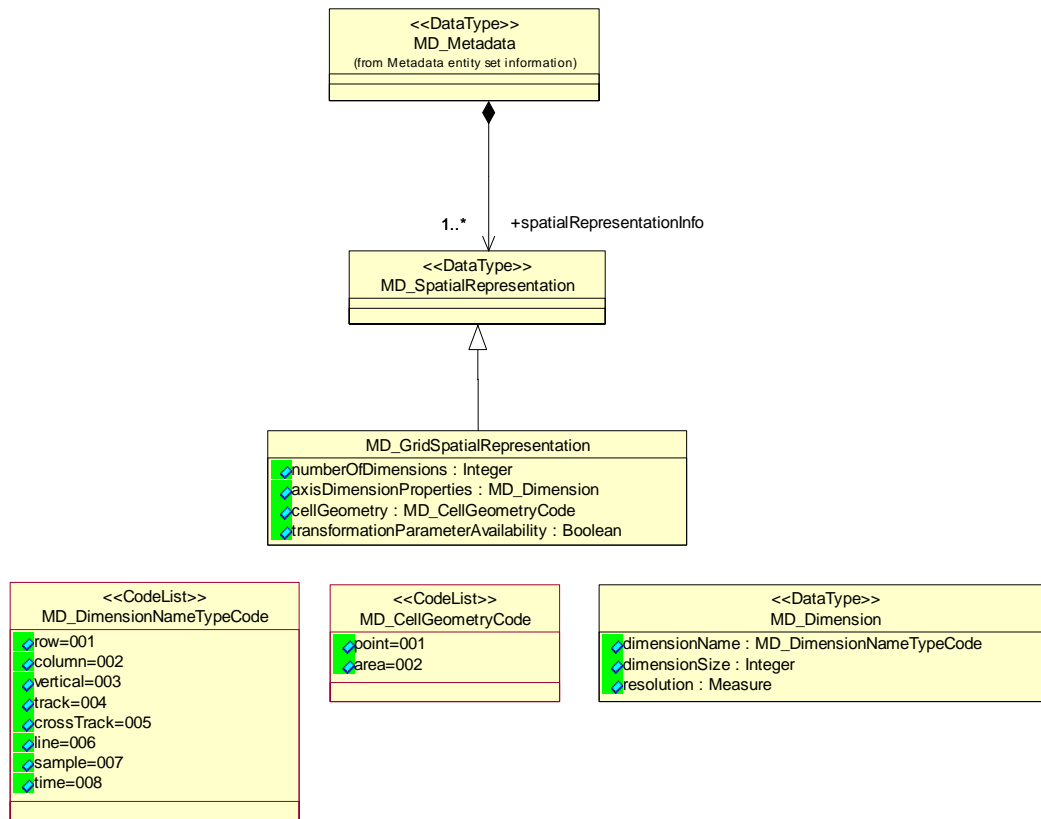


Figure 2-22. Terrain metadata – spatial representation

Figure 2-23 defines the metadata required to describe the spatial reference system used for terrain data.

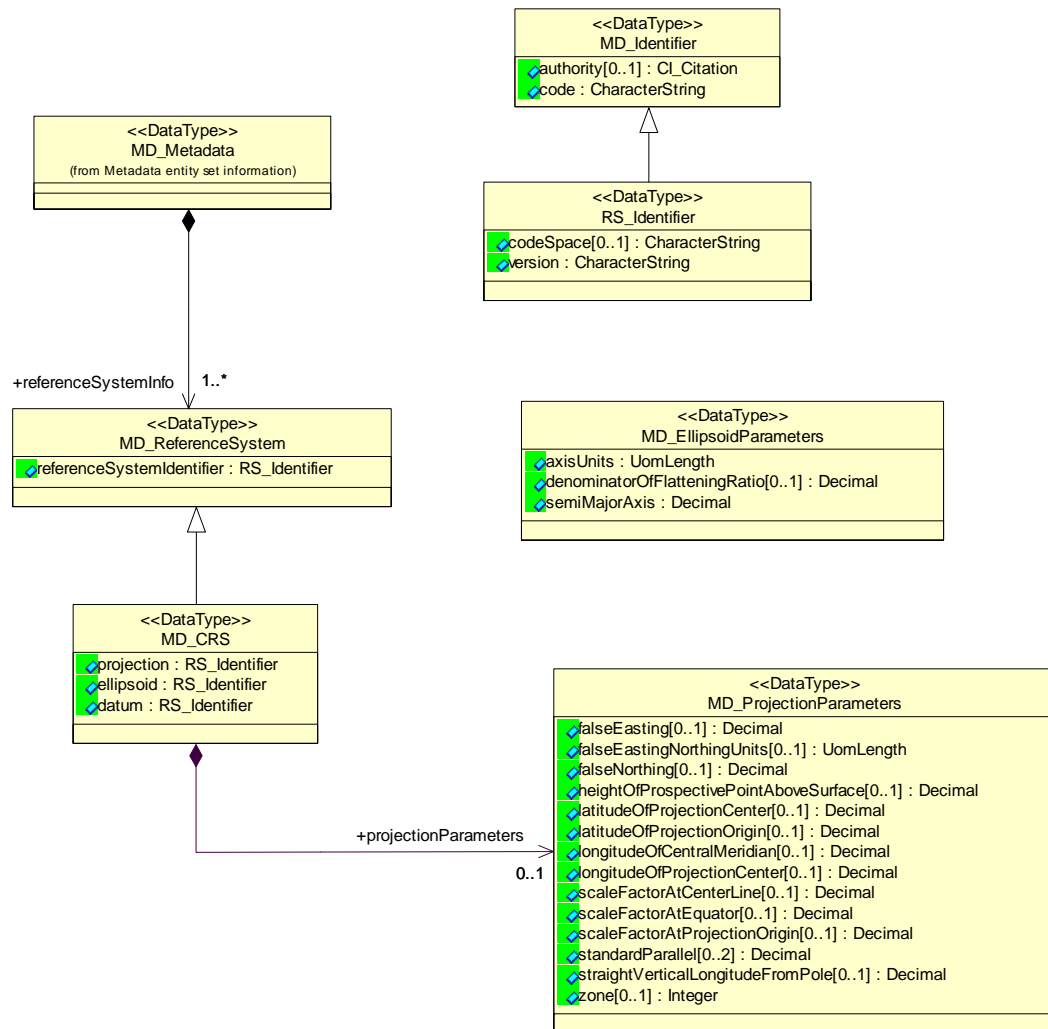


Figure 2-23. Terrain metadata – reference system

Figure 2-24 defines the metadata required to describe distribution information for terrain data.

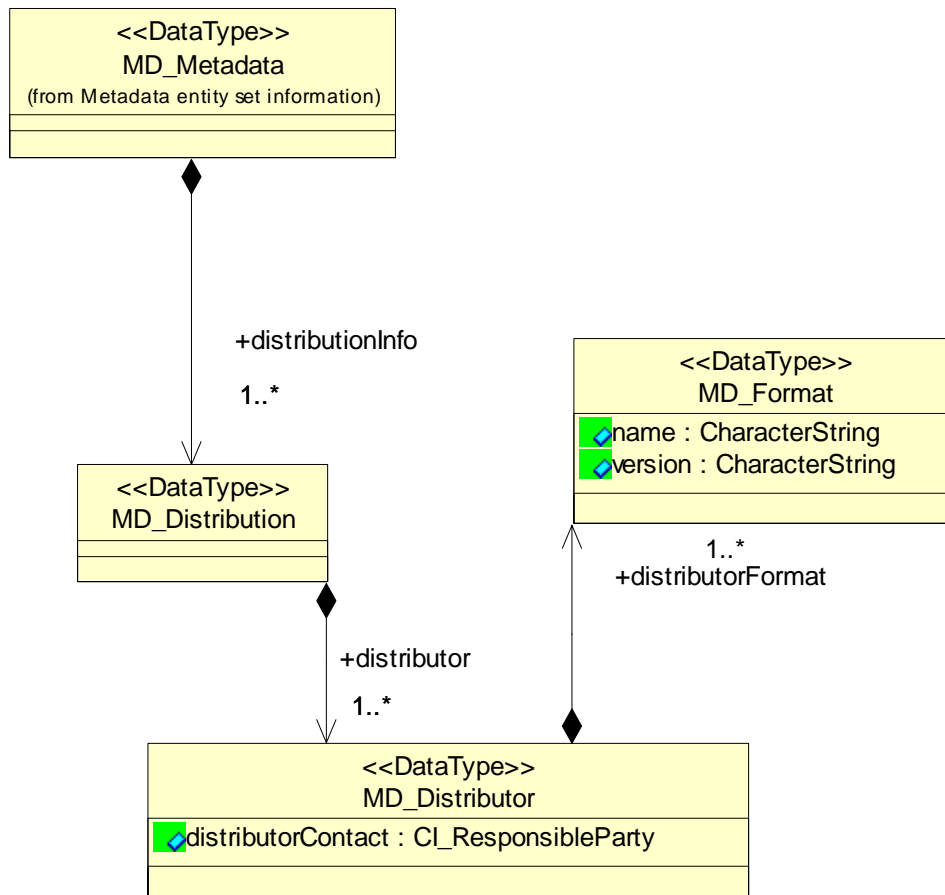


Figure 2-24. Terrain metadata – distribution

Figure 2-25 defines the metadata required to describe the spatial extent of terrain data.

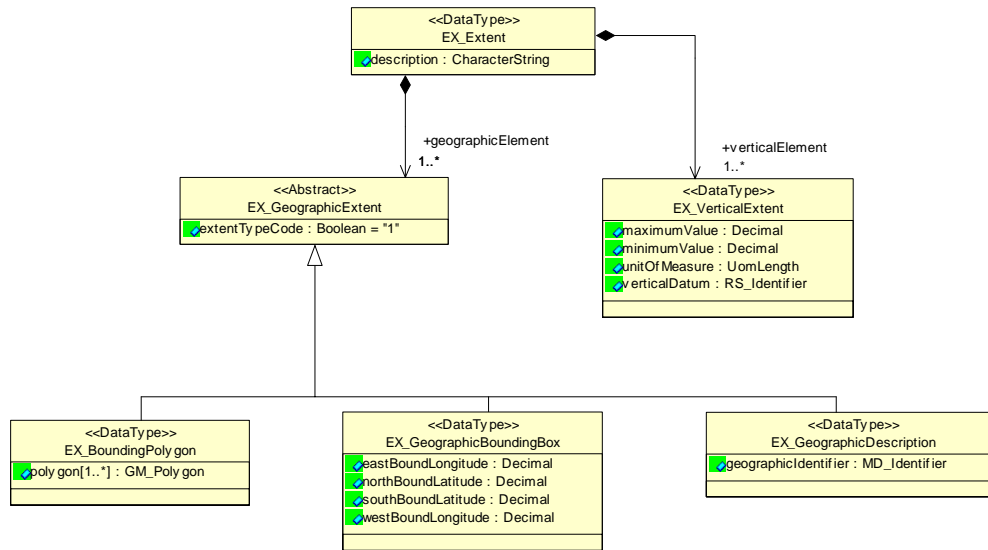


Figure 2-25. Terrain metadata – spatial extent

Figure 2-26 defines the metadata describing authoritative reference information, including responsible party and contact information for terrain data.

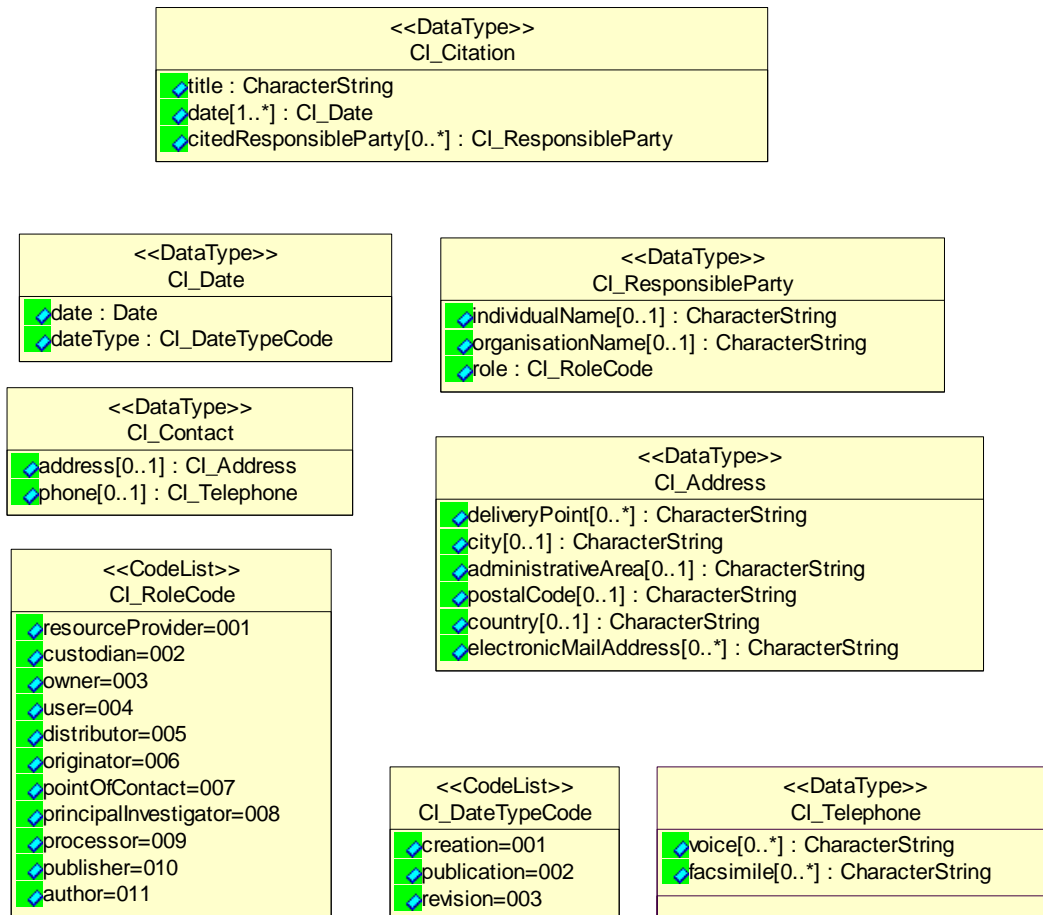


Figure 2-26. Terrain metadata – citation and responsible party

3 Obstacle Data

3.1 Scope

This chapter outlines requirements for obstacle data. Data originators require the quality characteristics to be defined, including specific numerical values in order to provide data for use in applications. Appendix A provides some illustrative application examples. Certification authorities and data users require information to ensure that obstacle data sets satisfy the intended applications. To assist the certification process of an application using obstacle data set(s), certification guidelines are provided in Appendix D.

This document provides the minimum user requirements applicable to the origination and publication of obstacle data from creation through the entire life cycle of the data. It provides a minimum list of attributes associated with the obstacle data and a description of associated errors that may need to be addressed. Any data processing must be accomplished in accordance with known and established quality processes and procedures.

The obstacle data numerical values in Chapter 3.2 are defined to accommodate the most stringent known application requirements, and not on a basis of acquisition cost. The integrity, accuracy, and resolution requirements specified in this document and the completeness of resulting data sets may not necessarily be sufficient for primary means of navigation.

3.1.1 Obstacle Definition

Obstacle: All fixed (whether temporary or permanent) and mobile objects, or parts thereof, that are located on an area intended for the surface movement of aircraft or that extend above a defined surface intended to protect aircraft in flight.

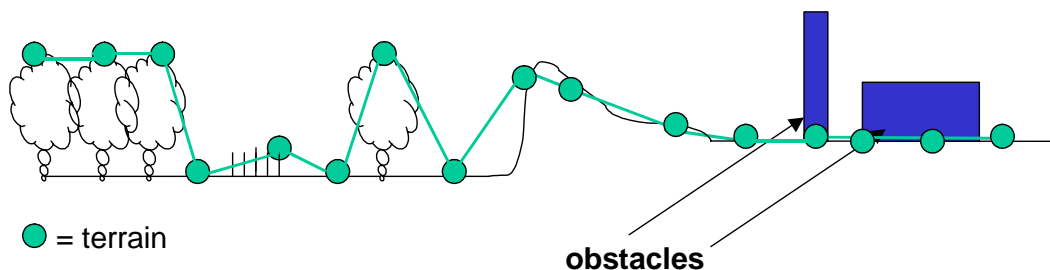


Figure 3-1. Obstacle definition

The term “obstacle” is used in Annex 4 solely for the purpose of specifying the objects to be included on charts. Obstacles are specified in other terms in Annex 14, Volumes I and II, for the purpose of clearing and marking. In certain databases, the single tree and/or the forest in the Figure 3-1 may be considered as obstacle.

3.1.2 Obstacle Data Attributes

An obstacle is an individually identified object of limited spatial extent. Some of the object's characteristics are captured in the database. Obstacles are not included in a terrain database. Obstacle data elements are features, which are represented by points, lines or polygons (see Chapter 3.3).

Obstacle data comprise the digital representation of the vertical and horizontal extent of man-made and natural significant features such as isolated rock pillars and natural vegetation (trees). Obstacle data include those features which have vertical significance in relation to adjacent and surrounding features and which are considered as potential hazards for air navigation.

Specific attributes associated with moveable or temporary obstacles are not included in this document.

Table 3-1 lists the minimum number of attributes that must be recorded for obstacle data that will be used in aviation applications.

Table 3-1. Obstacle Attributes

Attribute	Mandatory/ Optional	Type of attribute
Area of Coverage	Mandatory	Metadata
Data Originator Identifier	Mandatory	Feature Attribute
Horizontal Position Data	Mandatory	Feature Attribute
Horizontal Reference System	Mandatory	Metadata
Horizontal Resolution	Mandatory	Metadata
Horizontal Extent	Mandatory	Feature Attribute
Horizontal Accuracy	Mandatory	Feature Attribute
Horizontal Confidence Level	Mandatory	Feature Attribute
Elevation	Mandatory	Feature Attribute
Height	Mandatory	Feature Attribute
Database Units	Mandatory	Metadata
Vertical Reference System	Mandatory	Metadata
Vertical Resolution	Mandatory	Metadata
Vertical Accuracy	Mandatory	Feature Attribute
Vertical Confidence Level	Mandatory	Feature Attribute
Obstacle Type	Mandatory	Feature Attribute
Integrity	Mandatory	Feature Attribute
Date and Time Stamps	Mandatory	Feature Attribute
Effectivity	Optional	Feature Attribute
Status	Mandatory	Feature Attribute
Lighting	Mandatory	Feature Attribute
Marking	Mandatory	Feature Attribute
Geometry	Mandatory	Feature Attribute

3.1.2.1 Area of Coverage

Area of coverage is a description used to identify the boundary of obstacle data. This should be used to help the user identify in general terms the area under consideration.

3.1.2.2 Data Originator Identifier

Data originator identifier uniquely identifies the obstacle data originator. Sufficient information must be provided to distinguish between multiple data originators. A permanent record of the originator must be kept to establish an audit trail.

3.1.2.3 Horizontal Position

Horizontal position must be expressed as a point, or points defining a line or a polygon. Horizontal position must be expressed in geographic coordinates by latitude and longitude.

3.1.2.4 Horizontal Reference System

The horizontal reference system is the datum to which the positions of the data points are referenced. Coordinates used for air navigation must be expressed in the WGS-84 reference system. If the horizontal reference system is not WGS-84, the reference system and transformation parameters to WGS-84 must be specified.

3.1.2.5 Horizontal Resolution

Horizontal resolution can have two components:

- The units used in the measurements. Position recorded in one-arc second increments has higher resolution than that taken in one-arc minute increments
- The number of decimal places for the recording of the position. Use of more decimal places provides for higher resolution.

3.1.2.6 Horizontal Extent

The horizontal extent is the footprint of or the area subtended by the obstacle, e.g. area covered by mast guy wires, or weather balloon. Horizontal extent must be expressed in linear units that are consistent with the elevation specifications.

3.1.2.7 Horizontal Accuracy

Horizontal accuracy must be stated in the same units as used for the elevation. The statistical derivation of the horizontal accuracy must also be stated. Bias and standard deviation should be provided. (For further details see Appendix C)

3.1.2.8 Horizontal Confidence Level

The confidence level of the position must be stated as a percentage.

3.1.2.9 Elevation

Elevation is the vertical distance of a point or a level, on or affixed to the surface of the Earth measured from the vertical reference system. For points obstacle, the elevation must be the elevation of the top of the obstacle. For line obstacles, the elevation must be given for each point defining the straight line. For polygon obstacles, the elevation must be given by the maximum elevation within the polygon.

Elevation must be expressed in a unit that is consistent within the data set.

3.1.2.10 Height

Height is the vertical distance of a level, point, or an object considered as a point, measured from a specific datum. Obstacle heights are normally referenced to the ground level (AGL). For point obstacles, the height must be the height of the top of the obstacle. For line obstacles, the height must be given for each point defining the straight line. For polygon obstacles, the height must be the maximum height within the polygon.

Height must be expressed in a unit that is consistent within the data set.

3.1.2.11 Unit of measurement used

For every obstacle attribute that requires it, the unit used must be stated and the unit must be consistent within the data set.

3.1.2.12 Vertical Reference System

The vertical reference system is the datum to which the elevation values are referenced. Mean Sea Level (MSL) is the required vertical reference system. The Earth Gravitational Model (EGM-96) must be used as the global gravity model. If a geoid model other than the EGM-96 is used, a description of the model used, including the parameters required for height transformation between the model and EGM-96 must be provided.

3.1.2.13 Vertical Resolution

Vertical resolution can have two components:

- The units used in the measurements (elevation recorded in one-foot increment has higher resolution than that taken in one-meter increment)
- The number of decimal places for the recording of the elevation (use of more decimal places provides for higher resolution).

3.1.2.14 Vertical Accuracy

Vertical accuracy must be stated in the same unit as used for the elevation. The statistical derivation of the vertical accuracy must also be stated. Bias and standard deviation should be provided (see Appendix C).

3.1.2.15 Vertical Confidence Level

The confidence level of the elevation must be stated as a percentage.

3.1.2.16 Obstacle Type

Obstacle type is a description of the recorded obstacle, e.g., tower, building, tree, power lines, windmill farms, or cable car. Obstacles may be temporary such as cranes, permanent such as TV transmission towers, moving, such as ships.

3.1.2.17 Integrity

The integrity of the data set must be expressed, indicating the probability of any single data element having been changed inadvertently since the creation of the data set.

3.1.2.18 Date and Time Stamps

Time stamps are information about the origination or modification date and time of the data set. Time stamps must refer to Universal Coordinated Time (UTC) while date stamps must refer to the Gregorian calendar.

3.1.2.19 Effectivity

Effectivity is a description of the date/time period for which an obstacle exists. For all temporary obstacles, effectivity must be provided. Effectivity must include:

- The time and date of building/setting up the obstacle (referenced to UTC and the Gregorian calendar)
- The time and date of dismantling/removing the obstacle (referenced to UTC and the Gregorian calendar)

3.1.2.20 Obstacle Status

When an obstacle is still being built, an indication “under construction” must be provided.

3.1.2.21 Obstacle Lighting

When an obstacle has lighting this information must be provided.

3.1.2.22 Obstacle Marking

When an obstacle has markings this information must be provided.

3.1.2.23 Geometry Type

Obstacles must be described either as points, lines, or polygons.

Point obstacles: the centre of the obstacle’s horizontal surface must be captured as a two-dimensional (2-D) or three-dimensional (3-D) point. Adjacent obstacles or groups of obstacles must be captured individually.

Line obstacles: the center of the obstacle’s horizontal surface must be captured as a two-dimensional (2-D) or three-dimensional (3-D) line. A line consists of a connected sequence of points. Start- and end-points of a line are referred to as start- and end-node. Connecting points that are in between start- and end-nodes are referred to as *vertices*. Vertices are intermediate points that define the line structure, curvature, or shape. A start-node and an end-node define a line’s directionality. A connection between a node and a vertice or between vertices must be a straight line.

Polygonal obstacles: A polygon is a surface described by a closed line (i.e. a line whose start-node and end-node are coincident). The closed line forms the outer edge of the surface. The inside of the polygon is defined by the left side in the order of vertices. Depending on the complexity of the obstacle, one or multiple polygons may be used to model the obstacle.

3.2 Obstacle Data Quality Requirements

3.2.1 Introduction

The following Chapter provides obstacle data quality requirements for originated data necessary to accommodate the most stringent known application requirements. It is recognized that some applications have less demanding requirements and that enhanced capabilities or services may be provided with data of a better quality. Future applications may necessitate additional requirements.

The integrity, accuracy, and resolution requirements specified in this document and the completeness of resulting data sets are not necessarily sufficient for primary means of navigation. The numerical values shown are not to be construed as system level or application specific requirements. System level or application specific requirements are dependent on a safety analysis of the entire system, of which the database is only one part. The following are examples of the applications that use obstacle data sets:

- Ground Proximity Warning System (GPWS) with forward looking terrain avoidance function
- Minimum Safe Altitude Warning (MSAW) system
- Determination of contingency procedures for use in the event of an emergency during a missed approach or take-off
- Aircraft operating limitations analysis
- Instrument Procedure Design (including circling procedure)
- Determination of en-route “drift down” procedures and en-route emergency landing location
- Advanced Surface Movement Guidance and Control System (A-SMGCS)
- Aeronautical chart production and on-board databases
- Flight simulator
- Synthetic Vision and
- Aerodrome/heliport obstacle restriction and removal

Applications listed above (except for A-SMGCS and charting) are addressed in Appendix A.

3.2.2 Areas of Coverage

The obstacle data quality (numerical) requirements are provided for the following areas:

Area 1: entire area of a State

Area 2: terminal control area

Area 3: aerodrome/heliport area

3.2.2.1 Area 1 — the State

Area 1 covers the entire State. The quality requirements for obstacles in Area 1 were derived from existing SARPs for en-route obstacles adjusted to reflect digital needs and are supported by present and anticipated surveying techniques. 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 in Table 3-2.

Table 3-1. Obstacle data quality requirements for Area 1 — the State

Quality Attributes	Area 1 – Continuous (the State)
Horizontal Accuracy	50.0 m
Data Classification Integrity Level	Routine (10^{-3})
Vertical Accuracy	30.0 m
Vertical Resolution	1.0 m
Confidence Level (1σ)	90%
Maintenance Period	As required

3.2.2.2 Area 2 —Terminal Control Area

Area 2 is the terminal control area as published in the Aeronautical Information Publication (AIP) of a State or limited to a maximum of 45 km from the aerodrome/heliport ARP (whichever is smaller). 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. Obstacles must be collected and recorded in accordance with the Area 2 quality requirements.

Obstacles in Area 2 (see Figure 3-2) are defined as any of the following:

- Any obstacle that penetrates the conical surface whose origin is at the edges of the 180 m wide rectangular area and at the nearest runway elevation measured along the runway centre line, extending at 1.2% slope until it reaches 120 m above the lowest runway elevation of all operational runways at the aerodrome (1.2% slope reaches 120 m at 10 km); in the remainder of Area 2 (between 10 km and the TMA boundary or 45 km radius, whichever is smaller), the horizontal surface 120 m above the lowest runway elevation; and
- In those portions of Area 2 where flight operations are prohibited due to very high terrain or other local restrictions and/or regulations, obstacles must be collected and recorded in accordance with the Area 1 requirements.

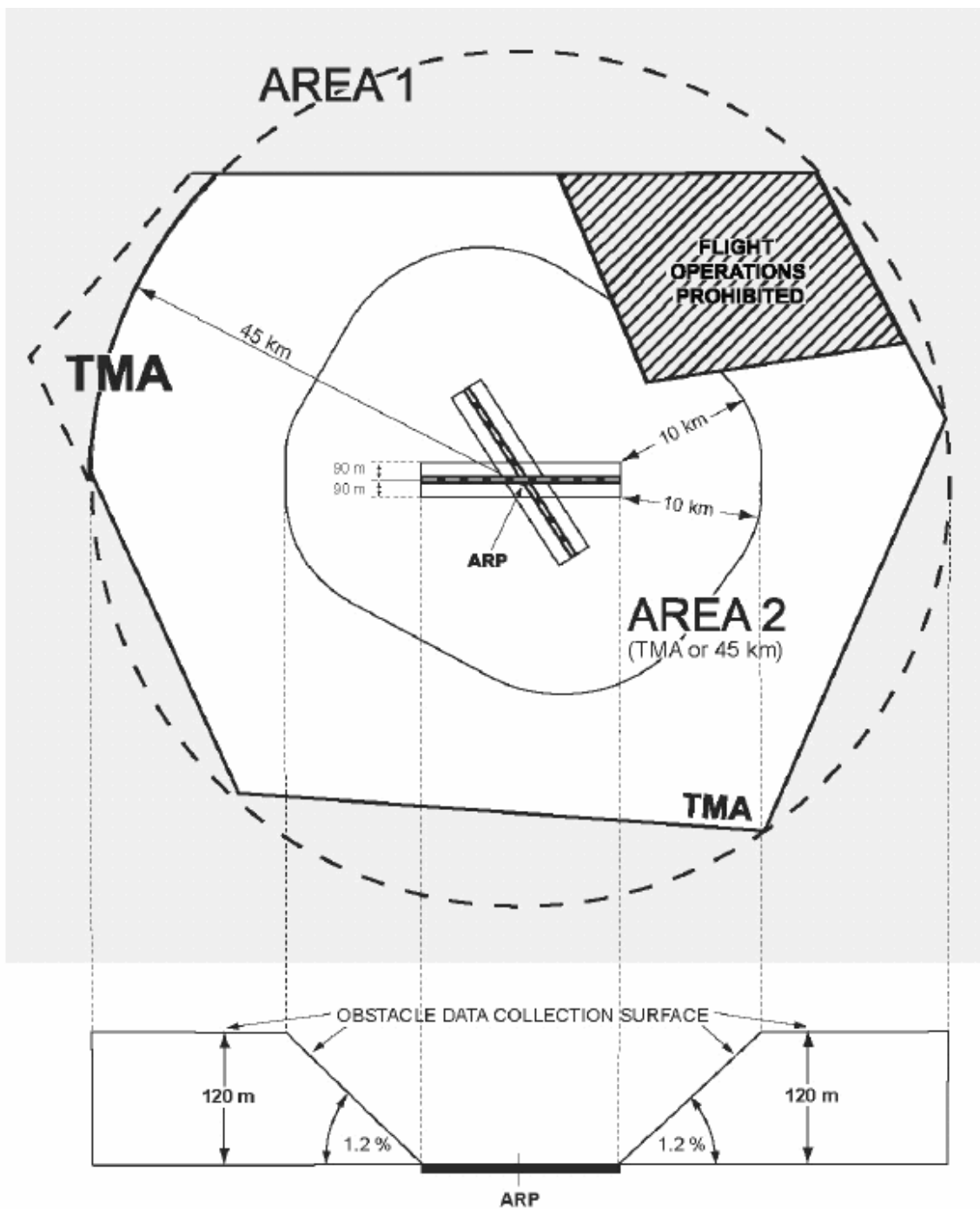


Figure 3-2. Obstacle data collection surfaces — Area 1 and Area 2

Area 2 obstacles must be recorded with the quality requirements listed in Table 3-3.

Table 3-2 Obstacle data quality requirements for Area 2 — Terminal Control Area

Quality Attributes	Area 2 — Terminal Control Area
Horizontal Accuracy	5.0 m
Data Classification and Integrity Level	Essential (10^{-5})
Vertical Accuracy	3.0 m
Vertical Resolution	0.1 m
Confidence Level (1σ)	90%
Maintenance period	As required

3.2.2.3 Area 3 - Aerodrome/Heliport Area

Note.- Detail guidance regarding obstacles and their collection in Area 3 — Aerodrome/Heliport Area is provided in Chapter 4 of this document.

When surveying obstacles at aerodromes/heliports, the horizontal surface extent to be surveyed must include the aerodrome movement area plus a buffer of 50 meters distance measured from the edges of the movement area (Figures 3-3 and 3-4 refer), or the minimum separation distances specified in Doc 9157, whichever is greater.

When surveying obstacles near runway, the horizontal surface extent to be surveyed must cover the area that extends from the edge(s) of the runway(s) to 90m distance measured from the runway centerline(s).

All obstacles identified within the horizontal surface extent area that extend more than 0.5 meters above the horizontal plane passing through the nearest point on the aerodrome movement area, may be hazardous for surface movement and must, therefore, be surveyed (Figure 3-4).

Obstacle data quality requirements for Area 3 are presented in Table 3-4.

Table 3-4. Obstacle data quality requirements for Area 3 — Aerodrome/Heliport Area

Quality Attributes	Area 3 — Aerodrome/Heliport Area
Horizontal Accuracy	0.5 m
Data Classification and Integrity Level	Essential (10^{-5})
Vertical Accuracy	0.5 m
Vertical Resolution	0.01 m
Confidence Level (1σ)	90%
Maintenance period	As required

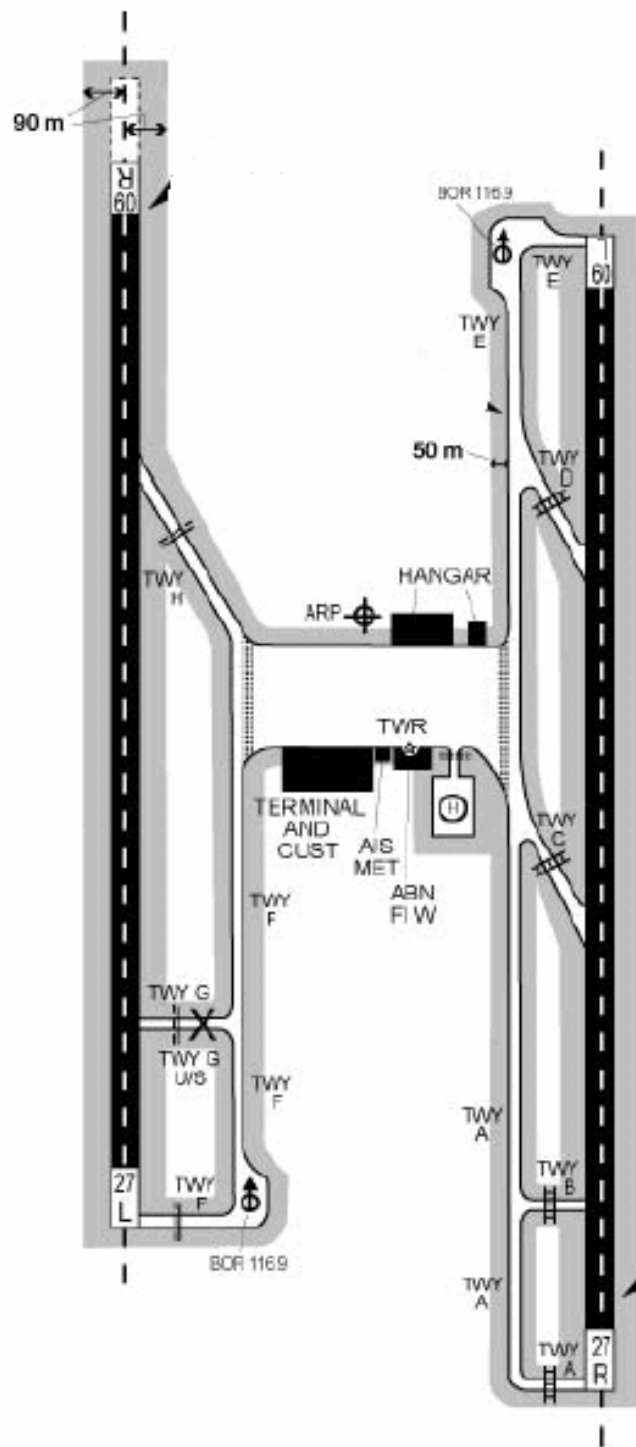


Figure 3-3. Obstacle data collection surfaces — Area 3

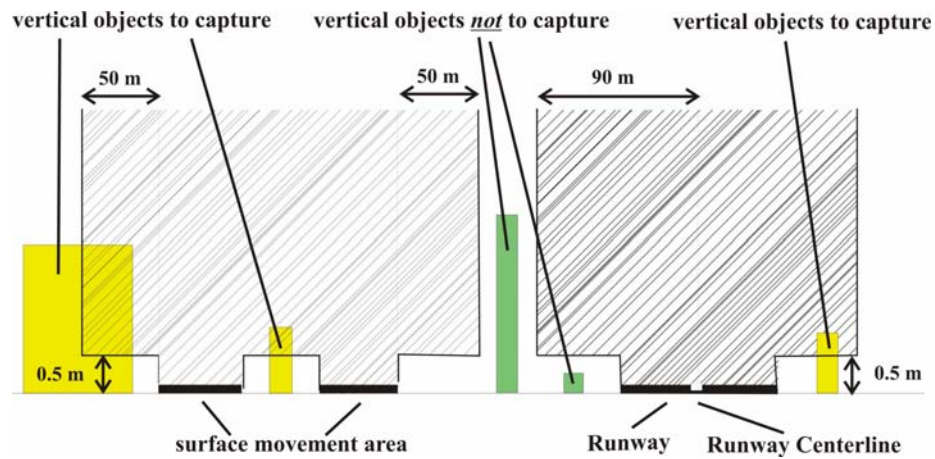


Figure 3-4. Capturing of obstacles (vertical objects) at aerodromes/heliports

Table 3-5. Summary of obstacle data quality requirements

Quality Attributes	Area 1 The State	Area 2 Terminal Control Area	Area 3 Aerodrome/ Heliport Area
Horizontal Accuracy	50.0 m	5.0 m	0.5 m
Data Classification Integrity level	Routine (10^{-3})	Essential (10^{-5})	Essential (10^{-5})
Vertical Accuracy	30.0 m	3.0 m	0.5 m
Vertical Resolution	1.0 m	0.1 m	0.01 m
Confidence Level (1σ)	90%	90%	90%
Maintenance period	as required	as required	as required

3.3 Data Product Specification

3.3.1 Overview

Obstacle data elements in an obstacle database are feature instances, which may be represented by points, lines, or polygons. An example of a point obstacle would be a light pole. An example of a line obstacle would be a power transmission line. An example of a polygonal obstacle would be a building. These are illustrated in Figure 3-5 a). Figure 3-5 b) illustrates a radius associated with a point obstacle specifying the extent of obstacle guy wires.

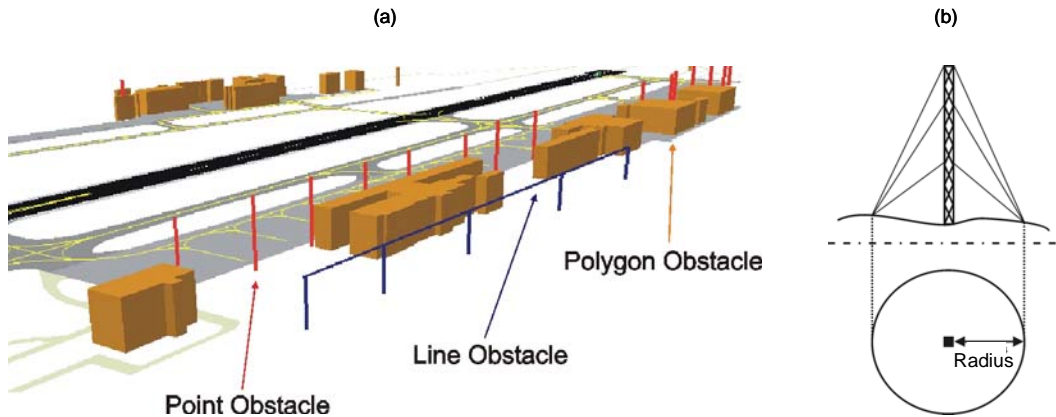


Figure 3-5. Obstacle features

3.3.2 Specification Scopes

An obstacle data product may not be homogeneous across the whole geographic area of the product, but may consist of subsets. For each such subset, the specification scope must be identified. Each subset may be defined by:

- » extent - the subset may have spatial, vertical or temporal extent constraints

Example: This product contains all obstacles with vertical extent greater than 200 meters AGL.

- » type - the subset may be defined according to obstacle feature type

Example: This product contains all water towers.

- » attributes - the subset may be defined by values of a set of feature attributes

Example: This product contains all obstacles which horizontal accuracy is less than 10 meters.

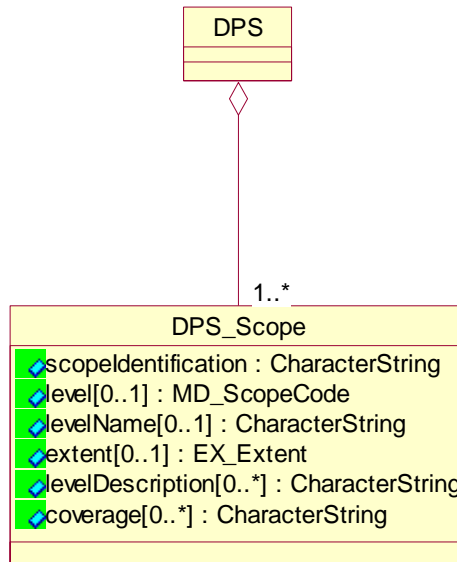
- » coverage - the subset may be a set of coverages within the data

Example: This product contains all Area 1 obstacles in France.

Requirements for identifying the specification scope for obstacle data products are listed in Table 3-6, while the UML model is given in Figure 3-6.

Table 3-6. Identification of specification scopes for obstacle data

Item Name	Definition	Obligation/ Condition	Mult.	Data Type	Domain
Scope identification	Identification of the scope for the purpose of a particular data specification	M	1	Character String	Free text
level	hierarchical level of the data specified by the scope	O	1	Class	MD_Scope Code <<codeList>>
levelName	name of the hierarchy level of the data specified by the scope	O	1	Character String	Free text
Extent	information about the spatial, vertical and temporal extent of the data specified by the scope	O	1	Class	EX_Extent
levelDescription	detailed description about the level of the data specified by the scope	O	N	Character String	Free text
Coverage	coverages to which the information applies	O	N	Character String	Free text

**Figure 3-6. UML model for obstacle data scope information**

3.3.3 Data Product Identification

Requirements for identifying obstacle data products are listed in Table 3-7, while the UML model is given in Figure 3-7. The mandatory items listed in Table 3-7 are further described below:

- » title - the title of the data product

Example: Worldwide Area 1 Obstacle Data Set.

- » abstract - a brief narrative summary of the content of the data product

Example: This product contains all obstacles in France with a vertical extent greater than 200 meters AGL.

- » topic category - the main theme(s) of the data product

Example: MD_TopicCategoryCode 017 – Structure.

- » geographic description - description of the geographic area covered by the data product

Example: The bounding polygon for this product is (-180.0, 180.0, -90.0, 90.0) [ISO 19115].

Table 3-7. Identification information for obstacle data

Item Name	Definition	Obligation/ Condition	Multi.	Data Type	Domain
Title	title of data product	M	1	Character String	Free text
Alternate Title	other name by which the data product is known	O	N	Character String	Free text
Abstract	brief narrative summary of the content of the data product	M	1	Character String	Free text
Purpose	summary of the intentions with which the data product is developed	O	1	Character String	Free text
Topic Category	main theme(s) of the data set	M	N	Class	MD_Topic Category Code <<CodeList>>
Spatial Representation Type	form of spatial representation	O	N	Class	MD_Spatial Representation Type Code
Spatial Resolution	factor which provides a general understanding of the density of spatial data in the data set	O	N	Class	MD_Resolution <<Union>>
Geographic Description	description of the geographic area within which data is available	M	N	Class	EX_Geographic Description
Supplemental Information	any other descriptive information about the data set	O	1	Character String	Free text

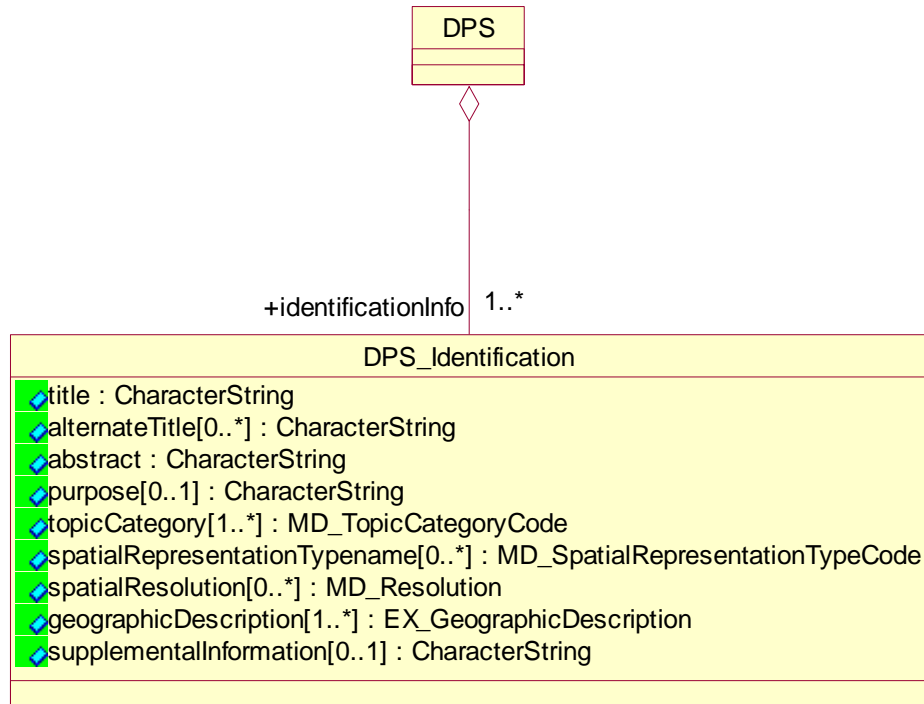


Figure 3-7. UML model for obstacle data identification information

3.3.4 Data Content and Structure

The interchange of obstacle data products must comply with the application schema and feature catalogue stated below.

3.3.4.1 Obstacle Application Schema

The obstacle data product application schema provides the common data model for obstacle data products. It complies with ISO 19109 (*Rules for Application Schema*) and uses Unified Modeling Language (UML) representations.

The application schema for obstacle data products reflects the requirements specified in Annex 15 and detailed in this document. This application schema is to be used by system implementers to establish conforming data interchange processes and formats. It is not, however, the intention of the application schema to impose a particular format, but rather to identify and standardize all common obstacle features and attributes, thereby enabling a standardized interchange of information.

Using the ISO 19100 series of standards for Geographic Information as the reference data-modeling framework implies an adherence to a common methodology with the intention to ensure interoperability. Therefore, ISO 19100 types have been used where appropriate. Moreover, in the case of metadata, the data structure has been derived from the ISO 19115 abstract metadata specification.

The application schema for obstacle data products is expressed using UML class diagrams in accordance with the ISO 19100 series of standards. These diagrams are shown in Figures 3-8 to Figure 3-11. The model integration diagram (Figure 3-8) shows the dependencies between the application schema and other standard packages.

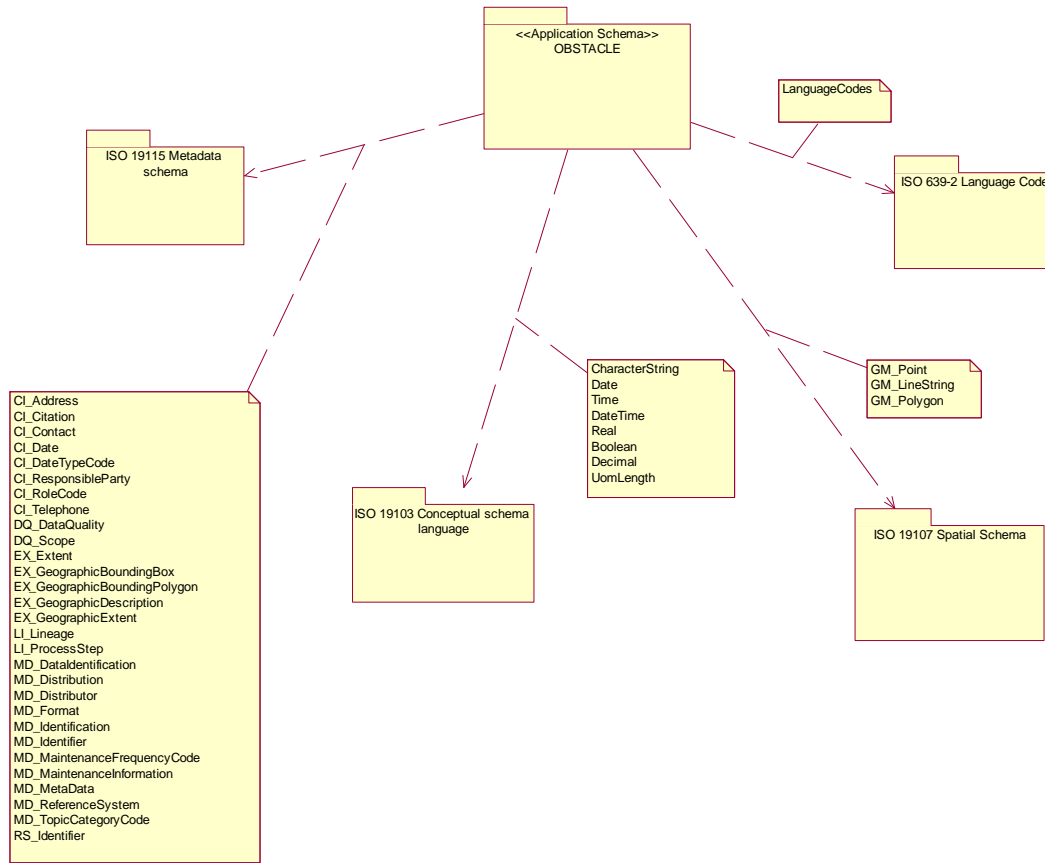


Figure 3-8. Model integration diagram for obstacle data

The application schema has been structured into two top-level packages, the feature types and the metadata types (Figure 3-9). Feature types reflect obstacle features and use attribute types and ISO 19100 types to define attributes and geometries. All obstacle features types use an abstract OB_FeatureBase type that contains the common attributes (Figure 3-10). UML model in Figure 3-11 defines the feature attribute enumeration types for obstacle data products.

Note 1. - features and attributes have been named according to the rules of ISO 19103.

Note 2. - the World-wide Web Consortium (W3C) string type is equivalent to the ISO 19103 CharacterString type.

Note 3. - code lists/enumerations are used to define an open/closed range of possible values or equivalent codes. The general format for an enumeration is (Label: Type = Code).

Note 4. - the default attribute multiplicity is 1; the multiplicity of an optional attribute is expressed as a range of values that begins with zero (e.g. [0..1]).

Note 5. - the feature base class and its inheritance are used to reduce the complexity of the diagrams; flat relational representations as shown in the Feature Catalogue may be implemented as well.

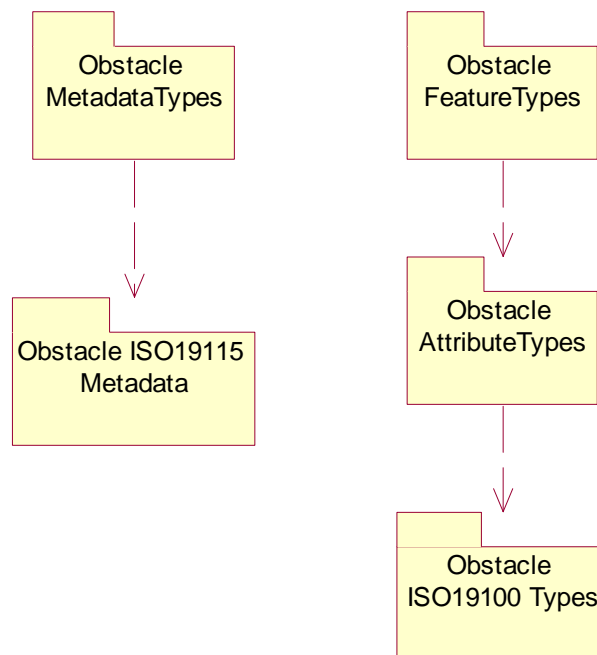


Figure 3-9. Application schema for obstacle data

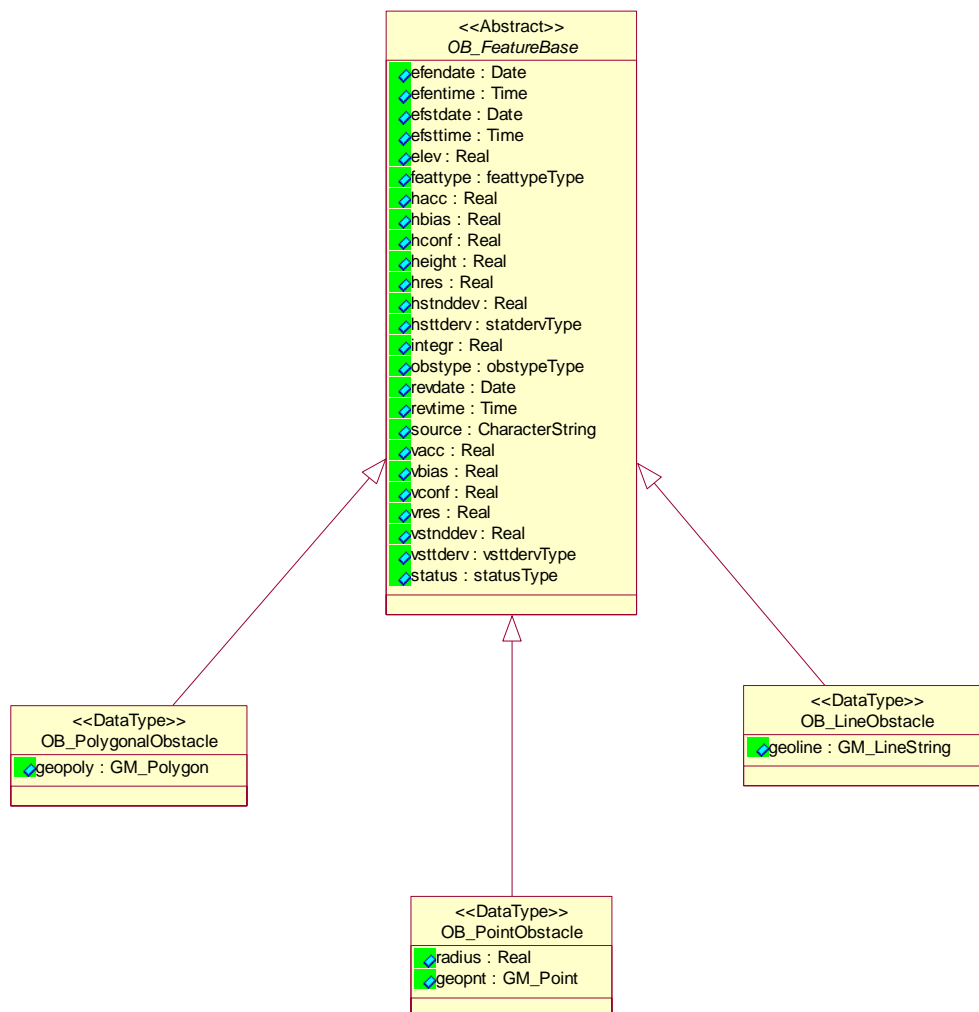


Figure 3-10. Feature types for obstacle data



Figure 3-11. Attribute enumeration types for obstacle data

3.3.4.2 Obstacle Feature Catalogue

This feature catalogue was developed in accordance with ISO 19110 and provides the minimum required set of attributes as defined previously within this document. Where feature attribute values are included, both the label and the code must be provided in the file that is to be interchanged.

Name: Obstacle Feature Catalogue

Scope: Features as specified in this document.

Version Number: 1.0

Version Date: <Insert final date/time of publication (e.g. 16.02.2007/18:00)>

Definition Source: *Annex 15 and Guidelines for Electronic Terrain, Obstacle and Aerodrome Mapping Information*

Definition Type:

Feature Type: 'PointObstacle'

Name: PointObstacle

Aliases: OB_PointObstacle

Definition: Obstacle with a limited horizontal extend represented as a point.

Attribute Names: feattype, source, hres, hacc, hsttderv, hbias, hstnddev, hconf, vres, vacc, vsttderv, vbias, vstnddev, vconf, integr, revdate, revtime, efstdate, efstime, efendate, efentime, elev, height, radius, obstype, status, geopnt,

Feature Type: 'LineObstacle'

Name: LineObstacle

Aliases: OB_LineObstacle

Definition: Obstacle with a linear horizontal extent represented by a line.

Attribute Names: feattype, source, hres, hacc, hsttderv, hbias, hstnddev, hconf, vres, vacc, vsttderv, vbias, vstnddev, vconf, integr, revdate, revtime, efstdate, efstime, efendate, efentime, elev, height, obstype, status, geoline,

Feature Type: 'PolygonalObstacle'

Name: PolygonalObstacle

Aliases: OB_PolygonalObstacle

Definition: Obstacle with a significant horizontal extent represented by a polygon.

Attribute Names: feattype, source, hres, hacc, hstderv, hbias, hstnddev, hconf, vres, vacc, vstderv, vbias, vstnddev, vconf, integr, revdate, revtime, efstdate, efstime, efendate, efentime, elev, height, obstype, status, geopoly,

Feature Attribute: 'feattype'

Name: feattype

Definition: Feature type.

Value Data Type: CharacterString

Value Measurement Unit:

Value Domain Type: 1

Value Domain: maximum 32 characters

Feature Attribute Values:

Label	Code	Definition
point_obstacle	0	Point Obstacle
line_obstacle	1	Line Obstacle
polygonal_obstacle	2	Polygonal Obstacle

Feature Attribute: 'source'

Name:	source
Definition:	Name of entity or organization that supplied data according to this document. In case of initial data origination, name of data originator.
Value Data Type:	CharacterString
Value Measurement Unit:	
Value Domain Type:	0
Value Domain:	maximum 64 characters
Feature Attribute Values:	

Feature Attribute: 'hres'

Name:	hres
Definition:	<i>Horizontal resolution</i> Horizontal resolution of coordinates (latitude, longitude) defining the feature position.
Value Data Type:	Real
Value Measurement Unit:	as specified in metadata horzUnit attribute.
Value Domain Type:	0
Value Domain:	[0.00000001, 1]
Feature Attribute Values:	

Feature Attribute: 'hacc'

Name:	hacc
Definition:	<i>Horizontal accuracy</i> Horizontal accuracy of entity.
Value Data Type:	Real
Value Measurement Unit:	as specified in metadata horzUnit attribute.
Value Domain Type:	0
Value Domain:	[0.00, 9999.99]
Feature Attribute Values:	

Feature Attribute: 'hsttderv'

Name: hsttderv

Definition: *Horizontal statistical derivation*

Statistical derivation distribution of the horizontal accuracy. Example: for Gaussian distribution: 0

Value Data Type: CharacterString

Value Measurement Unit:

Value Domain Type: 1

Value Domain:

Feature Attribute Values:	Label	Code	Definition
	Gaussian	0	Gaussian
	t	1	t-distribution
	Poisson	2	Poisson Distribution
	Weibull	3	Weibull Distribution
	Hypergeometric	4	Hypergeometric Distribution
	Geometric	5	Geometric Distribution
	F	6	F-distribution
	Exponential	7	Exponential Distribution
	Binomial	8	Binomial Distribution
	Cauchy	9	Cauchy Distribution

Feature Attribute: 'hbias'

Name: hbias

Definition: *Horizontal bias*
Horizontal accuracy bias.

Value Data Type: Real

Value Measurement Unit: as specified in metadata horzUnit attribute.

Value Domain Type: 0

Value Domain: [-9999.99, 9999.99]

Feature Attribute Values:

Feature Attribute: 'hstnddev'

Name: hstnddev

Definition: *Horizontal standard deviation*
Horizontal accuracy standard deviation (one sigma value).

Value Data Type: Real

Value Measurement Unit: as specified in metadata horzUnit attribute.

Value Domain Type: 0

Value Domain: [0.00, 9999.99]

Feature Attribute Values:

Feature Attribute: 'hconf'

Name: hconf

Definition: *Horizontal confidence*
The probability that the position values are within the stated horizontal accuracy of the true position.

Value Data Type: Real

Value Measurement Unit: percent

Value Domain Type: 0

Value Domain: [0.00, 100.00]

Feature Attribute Values:

Feature Attribute: 'vres'

Name:	vres
Definition:	<i>Vertical resolution</i> Vertical resolution of coordinates (height) defining the feature.
Value Data Type:	Real
Value Measurement Unit:	as specified in metadata vertUnit attribute.
Value Domain Type:	0
Value Domain:	[0.001, 99.99]
Feature Attribute Values:	

Feature Attribute: 'vacc'

Name:	vacc
Definition:	<i>Vertical accuracy</i> Vertical accuracy of entity.
Value Data Type:	Real
Value Measurement Unit:	as specified in metadata vertUnit attribute.
Value Domain Type:	0
Value Domain:	[0.00, 9999.99]
Feature Attribute Values:	

Feature Attribute: 'vsttderv'

Name: vsttderv

Definition: *Vertical statistical derivation*

Statistical derivation distribution of the vertical accuracy. Example: for Gaussian distribution: 0

Value Data Type: CharacterString

Value Measurement Unit:

Value Domain Type: 1

Value Domain:

Feature Attribute Values:	Label	Code	Definition
	Gaussian	0	Gaussian
	t	1	t-distribution
	Poisson	2	Poisson Distribution
	Weibull	3	Weibull Distribution
	Hypergeometric	4	Hypergeometric Distribution
	Geometric	5	Geometric Distribution
	F	6	F-distribution
	Exponential	7	Exponential Distribution
	Binomial	8	Binomial Distribution
	Cauchy	9	Cauchy Distribution

Feature Attribute: 'vbias'

Name:	vbias
Definition:	<i>Vertical bias</i> Vertical accuracy bias.
Value Data Type:	Real
Value Measurement Unit:	as specified in metadata vertUnit attribute.
Value Domain Type:	0
Value Domain:	[-9999.99, 9999.99]
Feature Attribute Values:	

Feature Attribute: 'vstnddev'

Name:	vstnddev
Definition:	<i>Vertical standard deviation</i> Vertical accuracy standard deviation (one sigma value).
Value Data Type:	Real
Value Measurement Unit:	as specified in metadata vertUnit attribute.
Value Domain Type:	0
Value Domain:	[0.00, 9999.99]
Feature Attribute Values:	

Feature Attribute: 'vconf'

Name:	vconf
Definition:	<i>Vertical confidence</i> The probability that the position values are within the stated vertical accuracy of the true position.
Value Data Type:	Real
Value Measurement Unit:	percent
Value Domain Type:	0
Value Domain:	[0.00, 100.00]
Feature Attribute Values:	

Feature Attribute: 'integr'

Name: integr

Definition: *Integrity*

Integrity of data is the degree of assurance that the data and its value have not been lost nor altered since the data origination or authorized amendment.

Value Data Type: Real

Value Measurement Unit:

Value Domain Type: 0

Value Domain: [0, 1]

Feature Attribute Values:

Feature Attribute: 'revdate'

Name: revdate

Definition: *Revision date*

Date of origination or last revision date of data in metadata temporal reference system.

Value Data Type: Date

Value Measurement Unit:

Value Domain Type: 0

Value Domain:

Feature Attribute Values:

Feature Attribute: 'revtime'

Name: revtime

Definition: *Revision time*

Time of origination or last revision of data in metadata temporal reference system.

Value Data Type: Time

Value Measurement Unit:

Value Domain Type: 0

Value Domain:

Feature Attribute Values:

Feature Attribute: 'efstdate'

Name: efstdate

Definition: *Effective set-up date*
effective obstacle building/setting up/erection date in metadata temporal reference system..

Value Data Type: Date

Value Measurement Unit:

Value Domain Type: 0

Value Domain:

Feature Attribute Values:

Feature Attribute: 'efsttime'

Name: efsttime

Definition: *Effective set-up time*
effective obstacle building/setting up/erection time in metadata temporal reference system. Optional: Conditional

Value Data Type: Time

Value Measurement Unit:

Value Domain Type: 0

Value Domain:

Feature Attribute Values:

Feature Attribute: 'efendate'

Name: efendate

Definition: *Effective removing date*
effective obstacle dismantling/removing date in metadata temporal reference system..

Value Data Type: Date

Value Measurement Unit:

Value Domain Type: 0

Value Domain:

Feature Attribute Values:

Feature Attribute: 'efentime'

Name: efentime

Definition: *Effective removing time*
effective obstacle dismantling/removing date in metadata temporal reference system..

Value Data Type: Time

Value Measurement Unit:

Value Domain Type: 0

Value Domain:

Feature Attribute Values:

Feature Attribute: 'elev'

Name: elev

Definition: *Obstacle elevation*
Maximum elevation of the top of object.

Value Data Type: Real

Value Measurement Unit: as specified in metadata vertUnit attribute.

Value Domain Type: 0

Value Domain: [-1499.9, 29999.99]

Feature Attribute Values:

Feature Attribute: 'height'

Name: height

Definition: *Obstacle height*
Maximum height of top of obstacle.

Value Data Type: Real

Value Measurement Unit: as specified in metadata vertUnit attribute.

Value Domain Type: 0

Value Domain: [0.00, 14999.99]

Feature Attribute Values:

Feature Attribute: 'radius'

Name:	radius
Definition:	<i>Radius</i> Radius of circle around center of obstacle including body of obstacle and associated structures including guy wires.
Value Data Type:	Real
Value Measurement Unit:	as specified in metadata vertUnit attribute.
Value Domain Type:	0
Value Domain:	[0.00, 2999.99]
Feature Attribute Values:	

Feature Attribute: 'obstype'

Name:	obstype		
Definition:	<i>Obstacle type</i> type of obstacle.		
Value Data Type:	CharacterString		
Value Measurement Unit:			
Value Domain Type:	1		
Value Domain:			
Feature Attribute Values:	Label	Code	Definition
	Arch	0	Arch
	Tethered Balloon	1	Tethered Balloon
	Bridge	2	Bridge
	Building	3	Building
	Catenary	4	Catenary
	Cooling Tower	5	Cooling Tower
	Crane	6	Crane
	Control Tower	7	Control Tower

Dam	8	Dam
Dome	9	Dome
Elevator	10	Elevator
Monument	11	Monument
Power Plant	12	Power Plant
Pole	13	Pole
Rig	14	Rig
Refinery	15	Refinery
Sign	16	Sign
Spire	17	Spire
Stack	18	Stack
Tank	19	Tank
Transmission Line Tower	20	Transmission Line Tower
Tower	21	Tower
Tramway	22	Tramway
Windmill	23	Windmill
Antenna	24	Antenna
Tree	25	Tree
Vegetation	26	Vegetation
Natural Highpoint	27	Natural Highpoint
Windmill Farms	28	Windmill Farms
Transmission Line	29	Transmission Line
Wall	30	Wall
Cable Railway	31	Cable Railway
Fence	32	Fence
Grain Elevator	33	Grain Elevator

Lighthouse	34	Lighthouse
Navaid	35	Navaid
Nuclear Reactor	36	Nuclear Reactor
Water Tower	37	Water Tower
Stadium	38	Stadium
Other	39	Other

Feature Attribute: 'status'

Name: status

Definition: *Obstacle status*
status of an obstacle.

Value Data Type: CharacterString

Value Measurement Unit:

Value Domain Type: 1

Value Domain:

Feature Attribute Values:	Label	Code	Definition
	Planned	0	Planned
	Under Construction	1	Under Construction
	Completed	2	Completed

Feature Attribute: 'geopoly'

Name: geopoly

Definition: *Polygonal obstacle*
Polygonal object.

Value Data Type: GM_Polygon

Value Measurement Unit: as specified in metadata horzUnit attribute.

Value Domain Type: 0

Value Domain:

Feature Attribute Values:

Feature Attribute: 'geoline'

Name: geoline

Definition: *Line obstacle*
Line object.

Value Data Type: GM_LineString

Value Measurement Unit: as specified in metadata horzUnit attribute.

Value Domain Type: 0

Value Domain:

Feature Attribute Values:

Feature Attribute: 'geopnt'

Name: geopnt

Definition: *Point obstacle*
Point object.

Value Data Type: GM_Point

Value Measurement Unit: as specified in metadata horzUnit attribute.

Value Domain Type: 0

Value Domain:

Feature Attribute Values:

Default Values

If no default values are given in the definition of attributes, then values given in Table 3-8 must be used.

Table 3-8. Default values for obstacle feature attributes

Attribute Format	Null	Unknown	Not Applicable	Not Entered
CharacterString	"\$Null"	"\$UNK"	"\$NA"	"\$NE"
Integer	-32768	-32767	-32765	-32764
Real	-32768.00	-32767.00	-32765.00	-32764.00
Date	00-00-0000	00-00-0001	00-00-0002	00-00-0003
Time	25:00:00	26:00:00	27:00:00	28:00:00

Supplemental Features

The feature catalogue provides the mandatory and optional features and feature attributes that may be included in a data set. While it is expected that these will satisfy most applications, supplemental features and feature attributes may be provided.

For supplemental features, specific rules concerning feature naming convention and mandatory information are used. Every supplemental feature should be described in a data interchange report file. For supplemental features, the following information is required: feature name, feature description, geometry type, derivation method, and data capture rule.

For supplemental features and feature attributes, the feature catalogue must be amended using ISO 19131.

Supplemental Feature Attributes

For supplemental features, the attributes listed in Table 3-9 must be provided.

Table 3-9. Required attributes for supplemental obstacle features

Attribute	Name	Description
Feature type	featype	Textual description of the feature type
Obstacle ID	idobst	Unique identifier for the feature
Data Source Identifier	source	Name of entity or organization that supplied data. In the case of initial data origination, name of data originator
Geometry	geopnt, geoline, geopoly	Point feature, line feature or polygonal feature, respectively
Elevation	elev	Maximum elevation of the top of the feature
Height	height	Maximum height of the top of the feature
Horizontal Extent	radius	Radius of circle around the center of the feature including the body of the feature and associated structures such as guy wires
Horizontal Accuracy	hacc	Horizontal accuracy of the recorded position
Horizontal Confidence Level	hconf	The probability that the recorded value is within the stated horizontal accuracy of the true value.
Vertical Accuracy	vacc	The vertical accuracy of the elevation of the feature
Vertical Confidence Level	vconf	The probability that the recorded value is within the stated horizontal accuracy of the true value
Integrity	integr	Integrity of data is the degree of assurance that the data and its value have not been lost nor altered since the data origination or authorized amendment
Time Stamp	revdate, revtime	Time of origination or last revision of data
Effectivity	efstdate, efstime, efendate, efentime	Start of construction or erection date and time, Dismantling or removal date and time

When there is a desire to specify feature attributes beyond those listed in Table 3-9 for supplemental features, the following rules concerning attribute naming conventions must be followed.

- » supplemental feature attribute names should end with “_s” for *supplemental*.
- » no duplicate names
- » only letters from the U. S. ASCII code (a..z)

- » maximum eight letters
- » only lower-case letters

For these additional feature attributes, attribute types must be one of the following:

- » `CharacterString` (not longer than 255 characters)
- » `Integer`
- » `Real`
- » `Date`
- » `Time`

Also, for these additional feature attributes, the following information must be provided:

- » name of the attribute
- » description of the attribute
- » feature type
- » fixed value for the attribute
- » maximum number of characters (for attributes of type `CharacterString`)
- » coding and labels (possible entries as defined by a code list)
- » units of measurement (e.g. meters, degree, etc.)
- » domain range (minimum and maximum value)

All codes required for any additional features, attributes, and/or code lists must adhere to the following rules:

- » code values must be described in the feature catalogue
- » codes should be of type `CodeList`
- » supplemental attribute codes must be greater than 100
- » no duplicate codes

Finally, all labels required for any additional features, attributes, and/or code lists must adhere to the following rules:

- » label values must be described in the feature catalogue
- » labels should be of type `CodeList`
- » supplemental attribute labels must end with the string “ SUPP”
- » no duplicate labels

Default Values

If no default values are given in the definition of attributes, then values given in Table 3-10 must be used.

Table 3-10. Default values for obstacle feature attributes

Attribute Format	Null	Unknown	Not Applicable	Not Entered
CharacterString	"\$Null"	"\$UNK"	"\$NA"	"\$NE"
Integer	-32768	-32767	-32765	-32764
Real	-32768.00	-32767.00	-32765.00	-32764.00
Date	00-00-0000	00-00-0001	00-00-0002	00-00-0003
Time	25:00:00	26:00:00	27:00:00	28:00:00

3.3.5 Reference Systems

The DPS must include information that defines the reference systems used in the data product. This must include the following:

- » the spatial reference system

Example: Horizontal locations are provided as latitude/longitude coordinates in decimal degrees (WGS-84); vertical values are provided in meters with respect to MSL.

- » the temporal reference system

Example: Time and date values are provided with respect to UTC and the Gregorian calendar.

The spatial reference systems used must be a reference system as defined in Annex 15. A coordinate reference system allows for the definition of horizontal and vertical datums. As required by Annex 15, the horizontal datum should be WGS-84, and the vertical datum should be MSL using appropriate geoid model such as EGM-96. The temporal reference system allows for obstacle data to be effective starting at a point in time until superseded.

The Gregorian calendar and Coordinated Universal Time (UTC) must be used as the temporal reference system for obstacle data products.

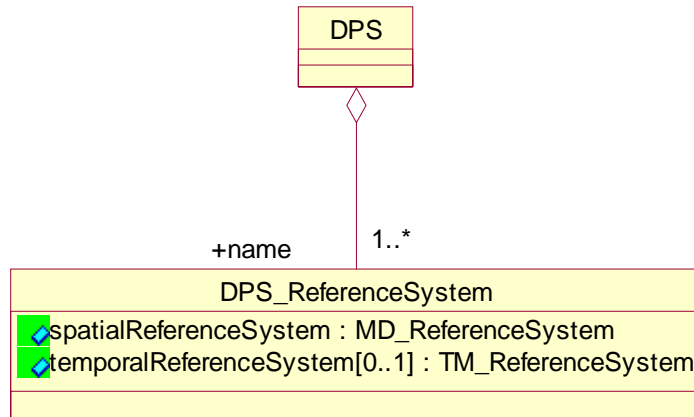
Reference system identifiers must identify the reference systems. These may take the form of either:

- » the names of the reference systems (e.g. WGS-84), or
- » codes for the reference systems, and a statement of the source of those codes (e.g. Code EPSG::4723 for WGS-84 [E. Petroleum Survey Group], Code WGE for WGS-84 [National Geospatial-Intelligence Agency and ARINC-424])

Requirements for identifying the reference system for obstacle data products are listed in Table 3-11, while the UML model is given in Figure 3-12.

Table 3-11. Reference system identification for obstacle data

Item Name	Definition	Obligation/ Condition	Multi.	Data Type	Domain
spatialReferenceSystem	identifier of spatial reference system	M	1	Class	MD_ReferenceSystem
temporalReferenceSystem	identifier of temporal reference system	O	1	Class	TM_ReferenceSystem

**Figure 3-12. UML model for reference system information for obstacle data**

3.3.6 Data Quality

Information about the quality of available obstacle data sets is vital to the process of selecting a data set in that the value of data is directly related to its quality. For the purpose of evaluating the quality of a data set, clearly defined procedures must be used in a consistent manner. Complete descriptions of the quality of a data set will encourage the sharing, interchange and use of appropriate obstacle data sets. This enables obstacle data producers to express how well their product meets the criteria set forth in its product specification and data users to establish the extent to which an obstacle data set meets their requirements.

For each obstacle feature, this document provides a set of quality parameters. These are listed in the feature catalogue and include:

- » Horizontal accuracy
- » Horizontal resolution
- » Horizontal confidence level
- » Vertical accuracy
- » Vertical resolution
- » Vertical confidence level
- » Data originator identifier
- » Data integrity
- » Time stamp

Data files must be protected by CRC (see Annex 15) to ensure that data is not corrupted during the interchange process. Each manufacturer, or customer, in the distribution chain is responsible for verifying that data is written protected by the appropriate CRC.

Requirements for identifying the quality of obstacle data products are listed in Table 3-12, while the UML model is given in Figure 3-13. For a more general discussion about quality conformance and reporting, refer to Appendix C of this document.

Table 3-12. Quality identification for obstacle data

Item Name	Definition	Obligation/ Condition	Multi.	Data Type	Domain
dataQuality	quality information concerning the data product	M	N	Class	DQ_DataQuality

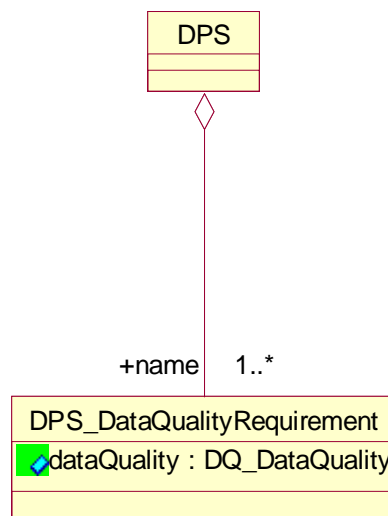


Figure 3-13. UML model for quality information for obstacle data

3.3.7 Data Capture

The scope of this data interchange standard does not include the process of data capture, although it is recognized that the content and the quality of an obstacle data product is significantly correlated with the process of data capture. Guidance for data capture of obstacles is provided in Chapter 3.2.

This DPS defines attributes and metadata that enable the results of the obstacle data capture methods to be communicated. In addition, the way in which data concerning real-world geo-spatial phenomena and characteristics of real-world phenomena are captured must be specified. The data to be included in this Chapter of the DPS must include a data capture statement that must be a general description of the process for the capture of the data.

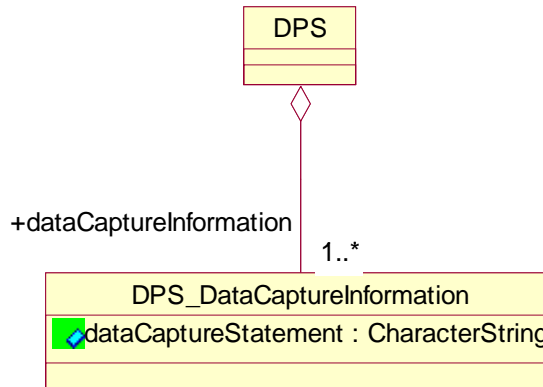
Conformance quality levels may need to be given for intermediate data, which may be required for the production of the data.

Requirements for identifying the data capture method for obstacle data products are listed in Table 3-13, while the UML model is given in Figure 3-14.

Table 3-13. Data capture identification for obstacle data

Item Name	Definition	Obligation/ Condition	Multi.	Data Type	Domain
dataCaptureStatement	general description of the process for the capture of the data	M	1	CharacterString	Free text

Example: The Worldwide Obstacle Data uses updated data received electronically, as well as data digitized from updated cartographic source. Data is blind re-keyed for verification purposes, where applicable, or is plotted and overlaid with scanned maps to verify location and to review pertinent attributes.

**Figure 3-14. UML model for data capture information for obstacle data**

3.3.8 Data Maintenance

Obstacle data sets are increasingly being used in dynamic environments: shared, interchanged, and used for purposes that require both accuracy and temporal relevance. Continuous maintenance and timely updates of obstacle databases is vital to the process of end-user applications.

Requirements for identifying the maintenance method for obstacle data products are listed in Table 3-14, while the UML model is given in Figure 3-15. For a more general discussion about maintenance, refer to Appendix D of this document.

Table 3-14. Maintenance identification for obstacle data

Item Name	Definition	Obligation/ Condition	Multi.	Data Type	Domain
Maintenance and update frequency	Frequency with which changes and additions are made to the product	M	1	Class	MD_MaintenanceFrequencyCode <<CodeList>>

Example: MD_MaintenanceFrequencyCode 010 reflects an irregular update cycle.

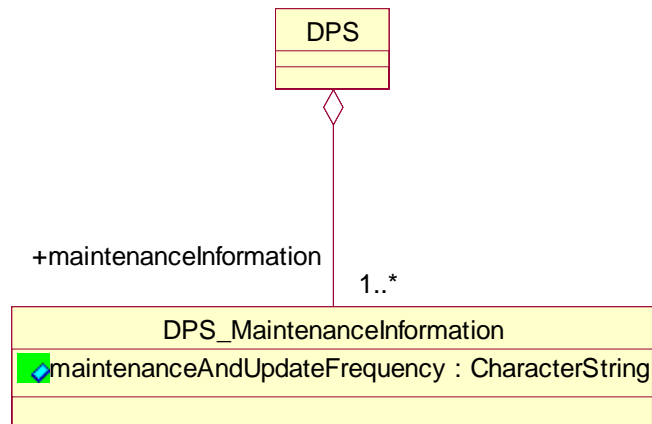


Figure 3-15. UML model for maintenance information for obstacle data

3.3.9 Portrayal

The obstacle DPS may provide information on how the data is to be presented as graphic output. If portrayal information is provided, applicable requirements are given in Table 3-15, while the UML model is given in Figure 3-16.

Table 3-15. Portrayal information for obstacle data

Item Name	Definition	Obligation/ Condition	Multi.	Data Type	Domain
portrayalCatalogueCitation	Bibliographic reference to the portrayal catalogue	C/if provided	N	Class	CI_Citation

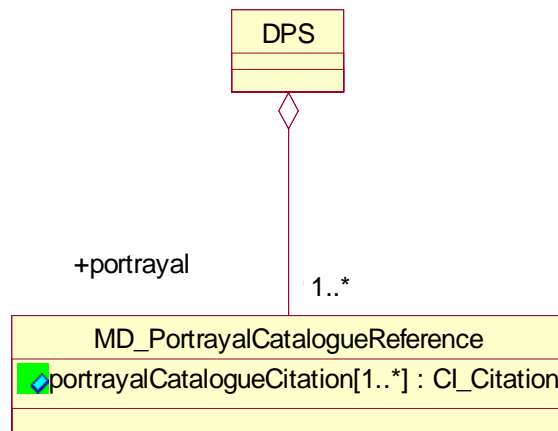


Figure 3-16. UML model for portrayal information for obstacle data

3.3.10 Data Product Delivery

This DPS contains no specific requirements for data product delivery, however, a compliant physical implementation of the DPS should identify the following elements: format name, version, specification, file structure, language, character set, units of delivery, transfer size, medium name, and other delivery information.

If data product delivery information is provided, applicable requirements are given in Tables 3-16 and Table 3-17, while the UML model is given in Figure 3-17.

Table 3-16. Delivery format information for obstacle data

Item Name	Definition	Obligation/ Condition	Multi.	Data Type	Domain
formatName	name of the data format	M	1	Character String	Free text
Version	version of the format (date, number, etc)	O	1	Character String	Free text
specification	name of a subset, profile, or product specification of the format	O	1	Character String	Free text
fileStructure	structure of delivery file	O	1	Character String	Free text
Language	language(s) used within the data set	M	N	Character String	ISO 639-2, other parts may be used
characterSet	full name of the character coding standard used for the data set	O	1	Class	MD_CharacterSetCode

Table 3-17. Delivery medium information for obstacle data

Item Name	Definition	Obligation/ Condition	Multi.	Data Type	Domain
unitsOfDelivery	description of the units of delivery (e.g. tiles, layers, geographic areas)	M	1	Character String	Free text
transferSize	estimated size of a unit in the specified format, expressed in Mbytes	O	1	Real	>0
mediumName	name of the data medium	O	1	Character String	Free text
otherDeliveryInformation	other information about the delivery	O	1	Character String	Free text

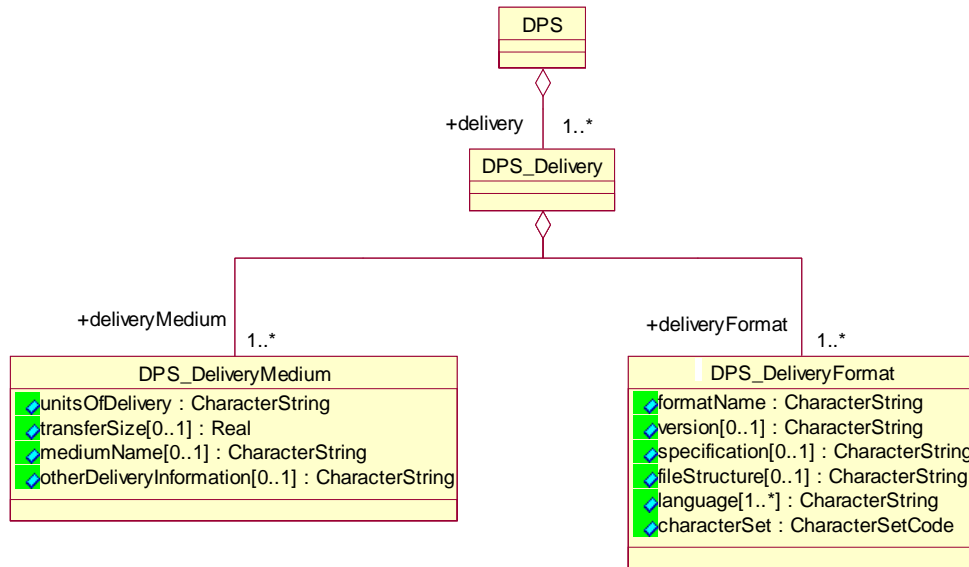


Figure 3-17. UML model for delivery information for obstacle data

3.3.11 Additional Information

This section of the DPS may include any other aspects of the data product not provided elsewhere in this document.

3.3.12 Metadata

The metadata requirements for obstacle data products are derived from ISO 19115. Metadata is classified as identification information, quality information, maintenance information, reference system information, distribution information, extent information, and citation information. The UML models for the required metadata are given in Figures 3-18 through 3-25. Descriptions of metadata elements and code lists are given in Appendices F and G, respectively.

The Obstacle Model integration diagram and the Obstacle Application Schema diagram are shown in Figure 3-8 and Figure 3-9, respectively. Figure 3-18 defines the class MD_MetaData, which is a composition of all the metadata entities that are required to support the interchange of obstacle data products.

Note: the following attributes are not part of ISO 19115, but are required by this interchange standard: horzUnit and vertUnit.

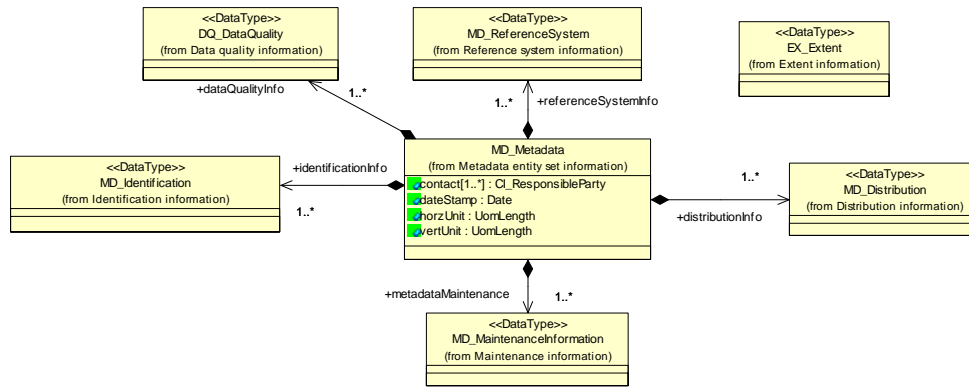


Figure 3-18. Obstacle metadata – overview

Figure 3-19 defines the metadata classes required to identify obstacle data.

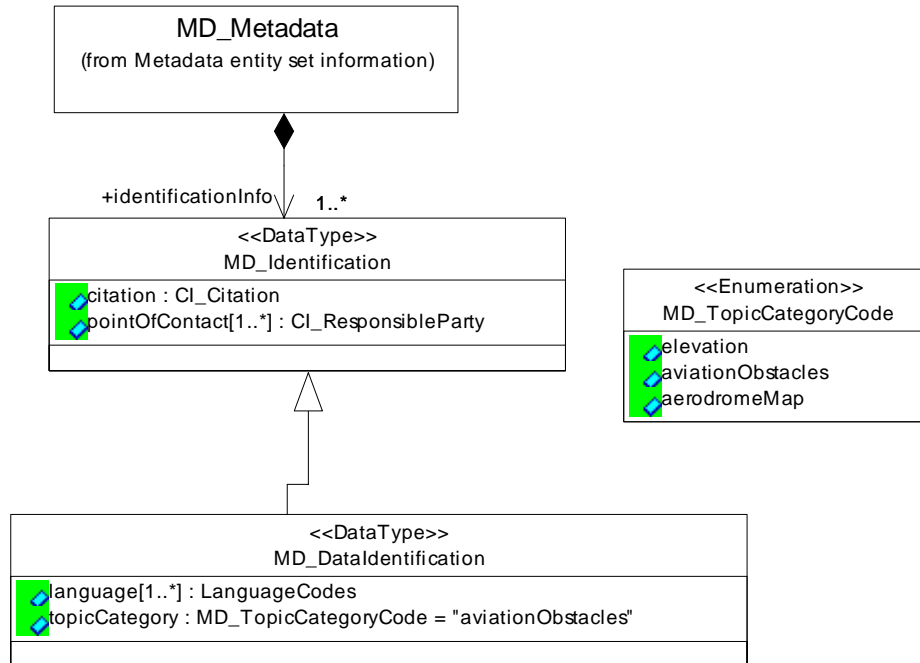


Figure 3-19. Obstacle metadata – identification

Figure 3-20 defines the metadata required to give an assessment of the quality and provide lineage information for obstacle data.

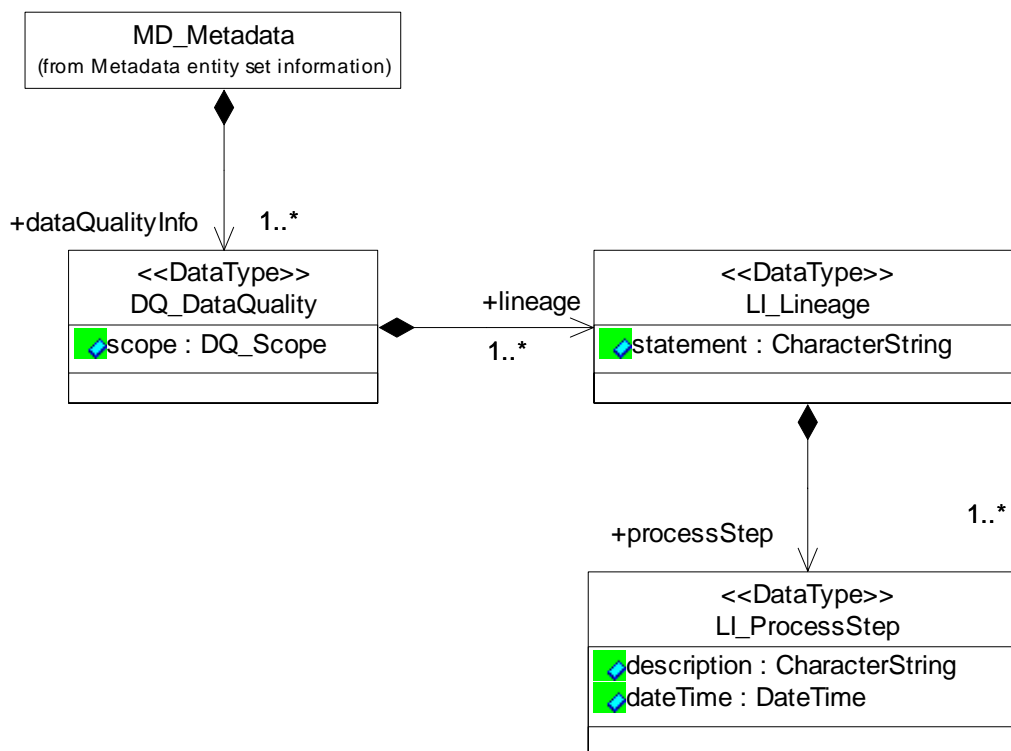


Figure 3-20. Obstacle metadata — quality

Figure 3-21 defines the metadata required to describe the maintenance and update practices for obstacle data.

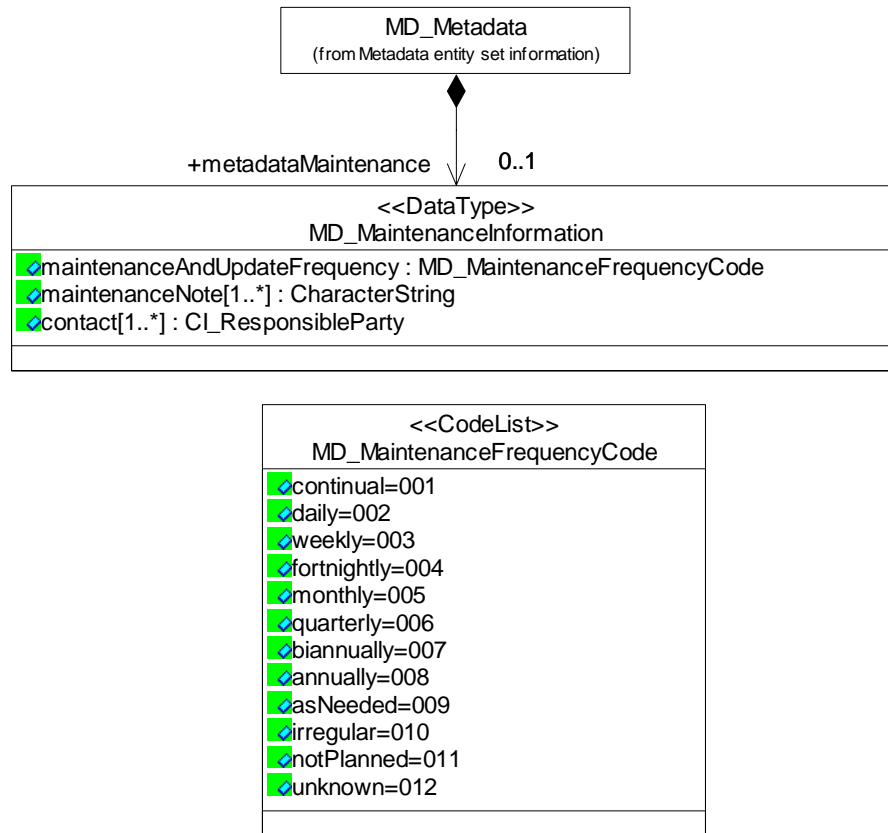


Figure 3-21. Obstacle metadata – maintenance

Figure 3-22 defines the metadata required to describe the spatial reference system used for obstacle data.



Figure 3-22. Obstacle metadata – reference system

Figure 3-23 defines the metadata required to describe distribution information for obstacle data.

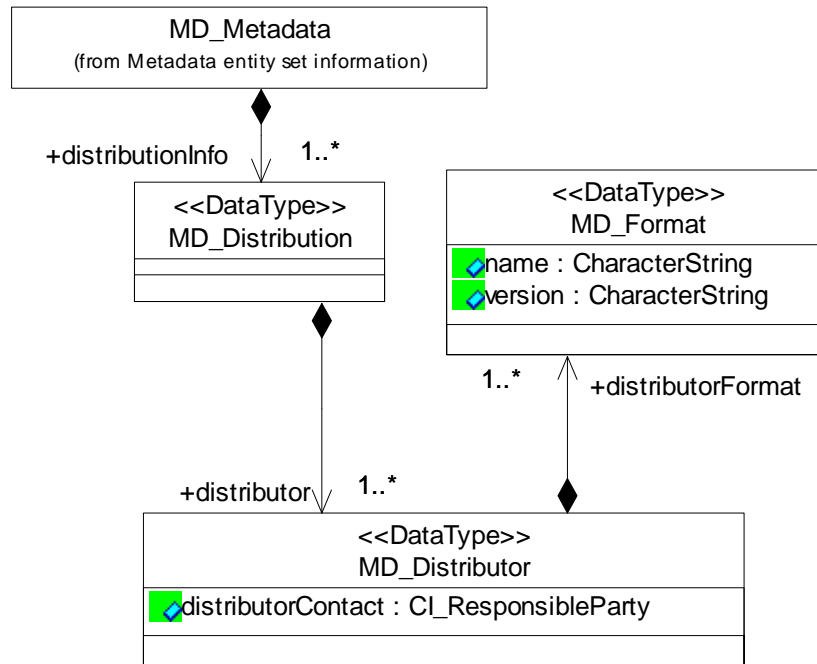


Figure 3-23. Obstacle metadata – distribution

Figure 3-24 defines the metadata required to describe the spatial extent of obstacle data.

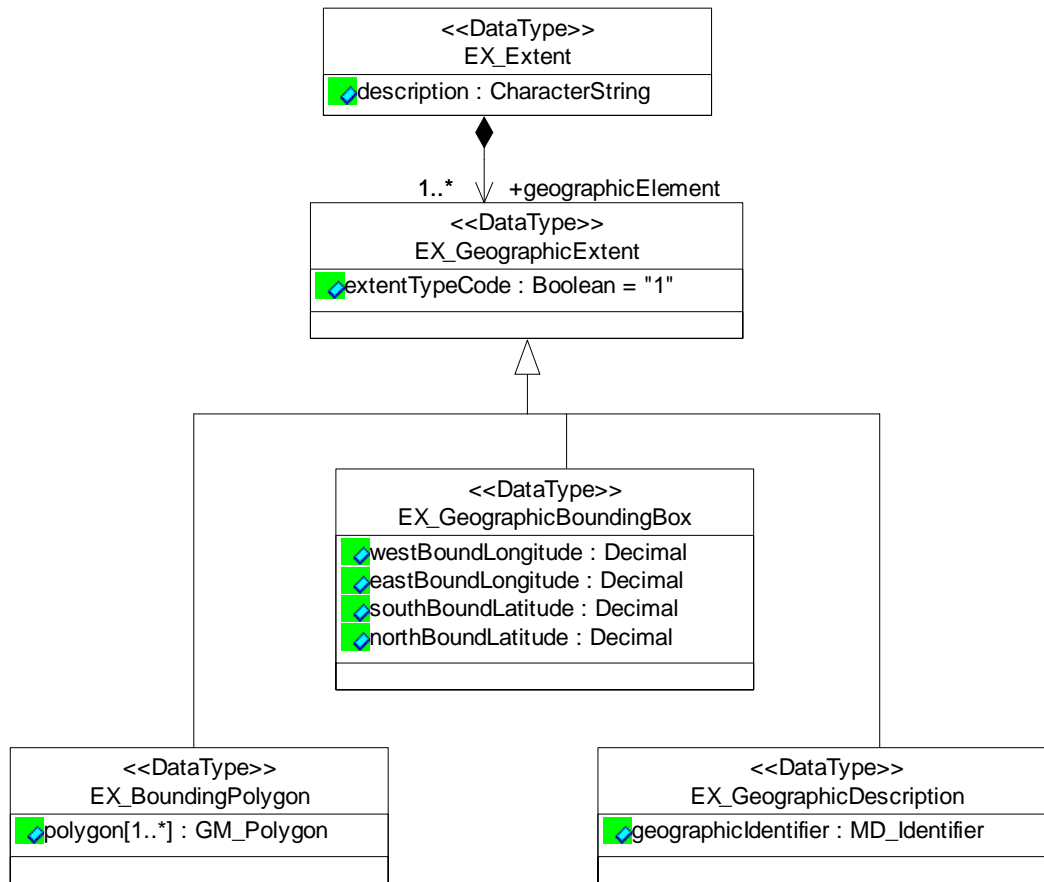


Figure 3-24. Obstacle metadata – extent

Figure 3-25 defines the metadata describing authoritative reference information, including responsible party and contact information, for obstacle data.

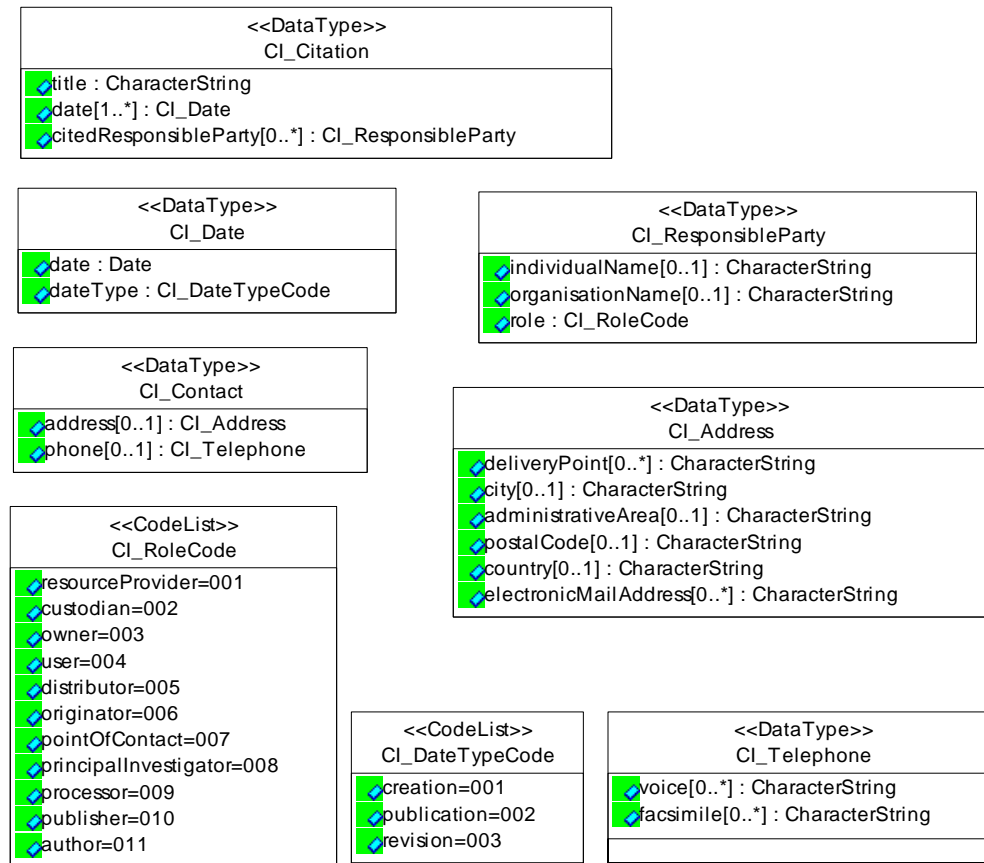


Figure 3-25. Obstacle metadata – citation and responsible party

4 Aerodrome Mapping Data

4.1 Introduction

4.1.1 Purpose

The information contained in this document has been compiled for the purpose of consolidating aerodrome surface mapping information requirements for aeronautical uses, particularly for aircraft on-board computers. The term aerodrome is used in this document to include: aerodromes, heliports, vertiports, and sea-plane aerodromes. As future applications are developed, more stringent data numerical requirements may be required. Aerodrome mapping data originators and integrators are urged to use this information when providing those data to system designers and users.

Based on the availability of one standardized aerodrome mapping database (AMDB), a wide variety of applications can be envisioned (see Appendix A). It is important to note that multiple user classes can benefit from using these databases, including: pilots, controllers, aerodrome managers, and aerodrome emergency/security personnel. Each of the applications listed below are described in detail in Appendix A.

- Runway operations
- Emergency and security service management
- Surveillance and runway incursion detection and alerting
- Aerodrome surface guidance and navigation
- Aerodrome facility and asset management
- Route and hold-short display and deviation detection and alerting
- Chart information
- Display of digital ATIS information
- Aerodrome and airline resource management
- Training (flight simulation)
- Notice To Airmen (NOTAM) and aeronautical data overlays
- Synthetic vision

4.1.2 Scope

This document provides minimum requirements and reference material applicable to the content, origination, publication, updating, and enhancement of aerodrome mapping information. The document also provides guidance to assess compliance and determination of the levels of confidence that need to be reached to support the types of applications listed in Appendix A. It should be used to support the development and application of AMDBs. The database represents a collection of aerodrome information that is organized and arranged for ease of electronic storage and retrieval in systems that support aerodrome surface movements, training, charting, and planning.

The dataset content generated/surveyed within the scope of this document will be interchangeable according to the rules defined in this document.

4.1.3 Aerodrome Mapping Information

4.1.3.1 Introduction

The advent of ground-based applications based on the use of aerodrome surface data and of onboard applications of aerodrome data to support safe, efficient surface movements, has necessitated the development of requirements and reference material applicable to such data.

Most of the existing standards and guidance materials are primarily applicable to air navigation data and were not written with aerodrome surface applications in mind. Issues specific to AMDBs include:

- Data may be derived from aerial survey and/or engineering drawings that are not traditional sources of aeronautical information
- Suppliers of aerodrome mapping data may not be familiar with typical civil aeronautical requirements, standards, and methods
- There are many different formats available for aerodrome mapping data (vector, raster, digital elevation models, etc.)

This document is intended to cover these specific issues so that the document can be submitted to the aviation community as a collection of disciplines necessary to provide assurance that the production of AMDBs meet the high quality required for safe aerodrome surface operations.

The starting point for aerodrome information is the data published by States in their Aeronautical Information Publication (AIP) in accordance with Annex 15. However, some specific detail required to support certain applications described in Appendix A is not reported on, as it may not be necessary for traditional aviation operations. Therefore, other sources of information for the aerodrome may be necessary for these applications.

4.1.3.2 Overview of geographic information systems (GIS)

The majority of existing AMDBs have been captured and maintained using Geographic Information Systems (GIS). GIS technology has evolved from the Computer-Aided Design (CAD) industry, combining the detailed information available in engineering drawings with a geographic reference system. A GIS is a computer program that combines geographically referenced digital data with spatial and attribute analysis tools. The strength of a GIS lies in the methods it provides to represent and analyze geographic information. A GIS can include many different types of data including: control networks, vector data, raster grid data, triangulated irregular networks (TINs), 3-D surface representations, remotely sensed data, and other digital source data such as geo-referenced drawings or Airport Layout Plans (ALPs) (see Figure 4-1). Within a GIS, these data sources can be combined, spatially referenced, and analyzed enabling the user to organize information and answer questions about the spatial relationships between the various thematic layers as well as the attribute characteristics of the features.

In addition to the use of GIS technology, AMDBs have also been realized by digitizing paper charts such as aerodrome obstacle charts, utilizing Computer-Aided Design (CAD) tools, and in the form of text or tabular files.

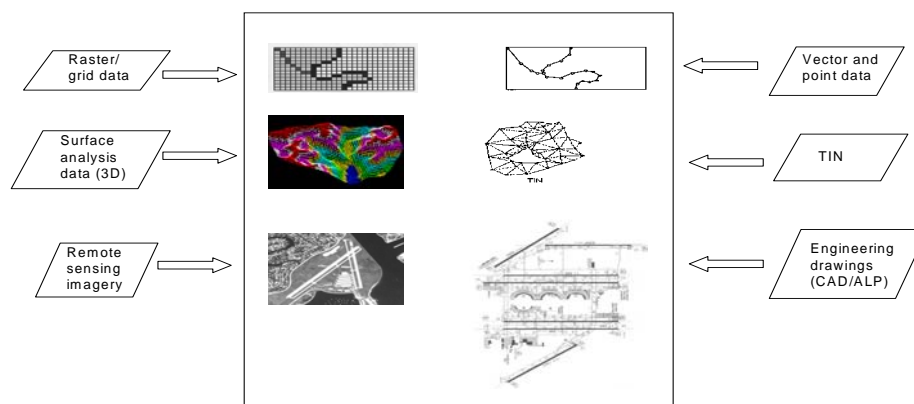


Figure 4-1. AMDB data layers

4.1.4 Aerodrome Mapping Data Considerations

4.1.4.1 Aerodrome Data

4.1.4.1.1 Characterization of Aerodrome Mapping Data

Unlike terrain databases, which are typically represented as grid points with associated elevation data, aerodrome databases are typically constructed from a photogrammetric image that is converted to vectors and assigned themes and attributes using GIS techniques. This is because many important data elements are features and not just elevations. These features are more easily characterized by points, lines, and polygons. Examples include runway edges, hold points, and stand locations. In other words, in AMDBs, not only should the aerodrome surface be properly represented (as is done in terrain databases), but also all existing natural or man-made objects (features) should be properly characterized.

The use of vector-based data has several advantages:

- Small data storage requirement
- Easy use of a relational database structure
- Easier updating
- No need of feature recognition software
- Easy attachment of attributes

Consequently, it is recommended that vector-based data (points, lines, and polygons) be used for the characterization of aerodrome features in AMDBs. An alternate approach is to use raster data or imagery. Using this approach, features are portrayed via contiguous pixels of equal or similar density number. This less precise method may be acceptable for some applications.

Aerodrome surface data, unlike terrain data, represents regular geometric objects that can be grouped or classified. Examples of classifications are: runways, taxiways, service roads, localizer antennas, glide slope antennas, buildings, radar sites, radio navigation facility sites, etc. All of these can be described with their own set of attributes, most of which are related to horizontal positioning. These attributes combine to provide a set of aerodrome data requirements that are distinguished from those of terrain data. This distinction must be recognized and preserved, since more attributes will be required to appropriately create the aerodrome images for use by different users including flight crews.

The array of attributes used to describe aerodrome features is not complete. It is imperative, to reduce the cost of systems that use the aerodrome data, to use standard representation classes and attributes. It is the intent of this document to define these requirements.

4.1.4.1.2 Aerodrome obstacle data

Aerodrome obstacles penetrate a defined obstacle identification surface. In determining obstacle data requirements, certain accuracy parameters are applied to construct buffers around obstacles and estimate whether they penetrate the defined surface. Depending on the area specified, unrealistically large, converging or overlapping buffers may be generated, resulting in high false alarm conditions. Internationally recognized survey standards should be used.

4.1.4.1.3 Aerodrome area terrain data

Consideration of terrain on and around the aerodrome is essential to terminal area airspace operations such as approach, departure, and contingency procedure planning. Hazards related to terminal area terrain awareness and avoidance have been cited as a major contributing factor in controlled flight into terrain (CFIT) accidents¹. Terrain is also important to aerodrome surface operations. It defines the surface topography of the ground in and around the surface movement areas. Since terrain data shares a physical boundary with many surface geometric objects on the aerodrome (runways, taxiways, buildings, etc.), it is important that the terrain data be correlated with these other data types.

4.2 Requirements

4.2.1 General Requirements

4.2.1.2 Data Acquisition

Any method is acceptable for capturing aerodrome mapping data subject to the information requirements specified in this document. Examples include: aerial photogrammetry, satellite photogrammetry, field surveying, and digitization of existing analog charts. A description of the process used to acquire aerodrome mapping data must be provided. This information must be consistent with this document.

4.2.1.3 Data Merging

In order to maintain data quality where multiple data sets are merged to create a complete AMDB, each individual data set must be geo-referenced to the WGS-84 ellipsoid (horizontal) and orthometric height (vertical). To avoid potential mismatch problems resulting from different features or themes being captured by different methods and/or originated from different sources, it is recommended that digital graphical editing procedures be used to align and/or match the shifted features using as reference the feature(s) that was geo-referenced with the highest accuracy.

¹ Flight Safety Foundation, CFIT Report, 1998

4.2.1.4 Data Conversion

Data sets may need to be converted to WGS-84 latitude/longitude (horizontal) and orthometric height (vertical); however, the original data, prior to the conversion, must meet the quality standards described in this document. Algorithms used to convert data to WGS-84 (horizontal) and orthometric height (vertical) must not degrade the data quality below levels described in this document.

4.2.1.5 Data Source Identification

The data originator must identify the source of any aerodrome mapping data provided to the user.

4.2.1.6 Data Traceability

The source data originator must produce adequate information such that the traceability of an AMDB can be maintained in accordance with the established quality procedures and processes. This can be accomplished with the provision of an appropriate metadata record for each contextual data sub set as described in this Chapter. Traditionally, a survey report generated by an accredited surveyor will contain sufficient information. If this type of survey report is generated, the data originators must release this report on request.

4.2.1.7 Database Update Cycles and Timeliness

Timeliness refers to updating AMDBs to account for new or change of existing data (e.g. due to construction activities) or some errors that have been identified. Presently, aerodrome data must be updated in accordance with the AIRAC cycle schedule. The AMDB may be updated more frequently than the standard AIRAC cycle schedule and information of changes that occur between AIRAC cycle updates may be provided by NOTAM, data link, or an equivalent method depending on the operational use of the data.

Given that the data has been correctly published or otherwise made available by the data originator, the data integrator must issue the updated database no later than the next AIRAC date. In addition, the integrator must provide a list of changes that have occurred since the previous issuance.

Database updates must be provided, at a minimum, for a complete, contextual AMDB sub-class (see Chapter 4.2.3). For example, if changes to runway markings are performed on the database, it is then the responsibility of the data manager to provide to its customers, at a minimum, the complete runway marking database contextual sub-class. The database manager or integrator has the option of providing a complete, updated AMDB or just the sub-class.

4.2.1.8 Processing, Handling, and Distribution of Aeronautical Data

It is essential that the integrity of aeronautical database products, as set forth in this document, be preserved during all phases of transfer, distribution, dissemination, or otherwise handling of the data. This applies equally to individual data elements as well as to the overall AMDB.

4.2.1.9 Verification and Validation

Sufficient verification and validation of all data must be performed such that the quality of the data is assured in accordance with this document. Additional validation may also be necessary for the benefit of suppliers and airworthiness authorities addressing certification of equipment or equipment components relying on the use of AMDBs because:

- AMDBs involve complex technology, that is relatively rapidly evolving

- The safety assessment may depend directly on a statement as to the overall quality of the AMDB
- Some aerodrome surface movement issues are not addressed by current airworthiness documents or guidance materials

In addition to the methods that are described in this document; adequate documentation of the measurement and mathematical transformation stages must be available for demonstration that the database has sufficient overall quality. However, other methods may be employed to make the demonstration.

The following techniques should be considered for the quality demonstration:

- Measurement of a sample of the database points with an independent measurement system. For example, the use of GPS equipment at specific points to compare to the same points in a database that was created by photogrammetric methods. The overall integrity of the database can be estimated to arbitrary levels of confidence depending on the number of samples that are checked: more samples give better confidence.
- Comparison of the target database to other recorded data such as certified record drawings and airport layout plans. In every case of comparison against other data, the vertical and horizontal references datums for the two data sets should also be compared.
- User feedback (e.g. pilot feedback through airline operations) could be a valuable validation method to verify the consistency, currency, and completeness of the database.
- Demonstration by actual use of the database including simulation, driving routes on the aerodrome, or flight test.

The combination of the validation techniques used needs to produce evidence that an appropriate subset of the data has been validated; meaning the subset of the database upon which the validation is performed is a representative sample of the aerodrome area covered by the database.

4.2.1.10 Supplier Qualifications

Suppliers must provide sufficient quality information with the aerodrome mapping data for the end user to verify and validate that the data is suitable for its intended use. Certification/accreditation of suppliers should consider demonstrating compliance with existing SARPs, civil aviation authority guidance material, other guidance material, and relevant ISO quality management standards.

4.2.1.11 Data Element Extent and Boundary Definition

A complete AMDB is composed of a variety of thematic data elements including, but not limited to, vertical objects, runways, taxiways, and building geometry. The methods employed to collect and handle each data type may differ widely. For example, vertical object data may be obtained using traditional ground-based aerodrome surveys. In addition to collection methods, the data types pose different hazards, risks, and informational opportunities to surface and terminal-area navigation applications. Therefore, the spatial or surveyed extent of the AMDB is defined on an element-by-element basis. Practical methods of data collection employed by industry (vis-à-vis aerodrome surveyors and GIS specialists) are also considered when defining the AMDB extent.

4.2.1.11.1 Vertical Objects

Requirements regarding the collection of vertical objects are given in Annex 15 through terrain/obstacle data collection surfaces. Applications requiring *Fine* quality data (see Chapter 4.2.2) require many elements in the movement area to be surveyed to sub-meter accuracy. Initially, these high-accuracy survey requirements will be imposed upon area in and around the movement areas. Rationale for the vertical extent boundary is driven by three considerations:

- wing-tip and airframe clearance requirements,
- air-ground (landing) and ground-air (take-off) proximity operations, and
- helicopter manoeuvring operations.

Criteria for surveying and collection of obstacles are provided in Chapter 3 of this document. Control towers must always be captured regardless of its location on the aerodrome.

4.2.1.11.2 Aerodrome Structure

Aerodrome structure is a general term used to describe the aerodrome terminal, tower, hangars, and other miscellaneous buildings on the aerodrome area. Based on the geometric complexity of these objects and their location in respect of the aerodrome operations, they are not traditionally surveyed, or in some cases, only the corners are surveyed. Future applications, particularly those with regard to efficiency and routing applications, will require detailed models of these geometric elements. Therefore, the following requirement is asserted:

Aerodrome structures must be modeled with a two-dimensional bounding polygon and a maximum height field, indicating the highest point on the building extent (bounding box). An example is shown in Figure 4-2. Towers and antennas protruding from the top of the building must be captured separately as vertical objects (obstacles).

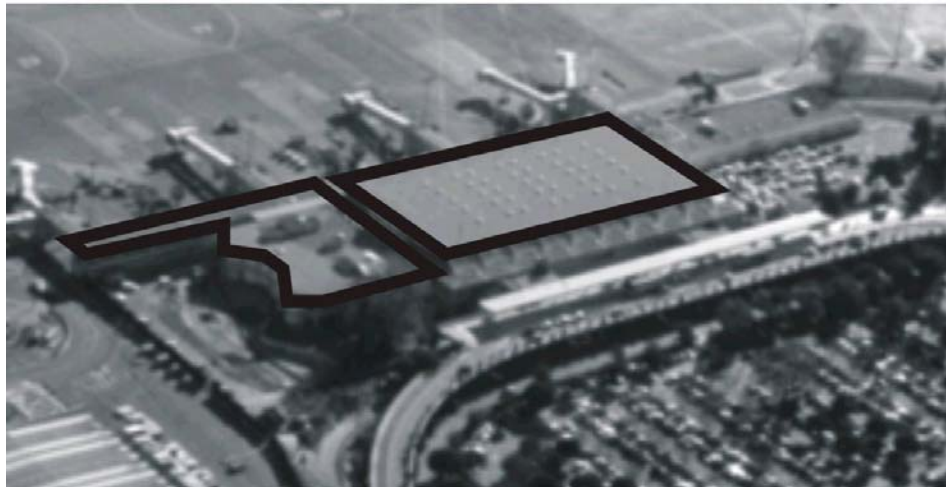


Figure 4-2. Aerodrome Structure Modeling Example

4.2.3 Specific Requirements for AMDBs

This Chapter provides specific requirements for AMDB content, capture rules, relationships, and quality.

4.2.3.1 Geometry

4.2.3.1.1 Geometrical Primitives

For the purpose of AMDBs, geometries must be described by points, lines, and polygons. Geometrical representations must ensure compliance with accuracy requirements (e.g. for a curve represented by a line, the density of the points must be sufficient to meet the accuracy requirement of the feature).

A point is the smallest unit of geometry and has no spatial extent. Points are described by two dimensional (2-D) or three-dimensional (3-D) coordinates.

A line consists of a connected sequence of points. Start- and end-points of a line are referred to as start- and end-node. Connecting points that are in between start- and end-nodes are referred to as vertices. A start-node and an end-node define a line's directionality. A connection between a node and a vertex or between vertices is a straight line.

A polygon is a surface described by a closed line (i.e. a line whose start-node and end-node are coincident). The closed line forms the outer edge of the surface. The inside of the polygon is defined by the left side in the order of vertices.

The symbols listed in Table 4-1 are used to represent the three geometrical primitives.

The symbols shown in Table 4-2 are used to represent the applicable geometric relationships. These representations do not imply any additional constraint requirements on the level of the geometry itself.

4.2.3.1.2 Geometrical Constraints

Geometrical constraints ensure connectivity between features on a spatial level. Compliance to geometrical constraints leads to graphical consistency of AMDB features with respect to the spatial connections observed in the real world. Generic geometrical constraints are applicable to all AMDB features of each geometry base type i.e. point, line, or polygon. Recommended geometrical constraints are listed in Table 4-3.

Table 4-1. Geometrical primitives






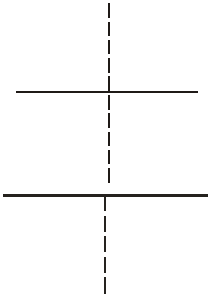



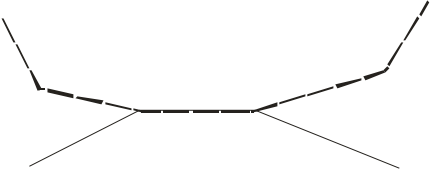




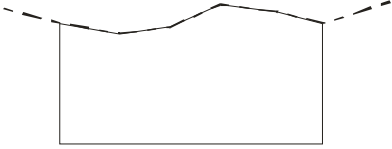
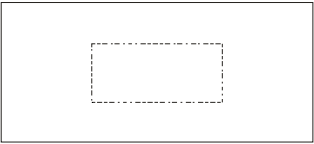
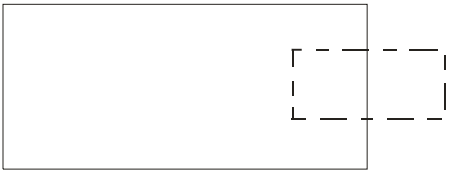
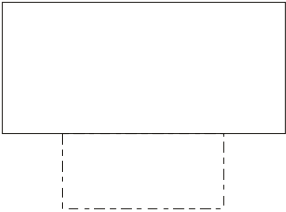
Symbol	Type
×	Point
—	Line
	Polygon

Table 4-2. Graphical depiction of geometrical relationships

Symbol	Geometries	Relationship Description
	Point – Polygon	... is located at the edge of ...
	Point – Polygon	... is contained in ...
	Point – Line	... is located on ...
	Line – Point	... ends at ...
	Line – Line	... crosses ...
	Line – Line	... starts/ends at the edge of ...
	Line – Line is connected to ...
	Line – Line overlaps ...
	Line – Line	...is attached to...
	Line – Polygon	... is contained in ...
	Line – Polygon	... intersects ...

Symbol	Geometries	Relationship Description
	Line – Polygon	... crosses ...
	Line – Polygon	... starts/ends at the edge of ...
	Line – Polygon	... is attached to ...
	Polygon – Polygon	... is contained in ...
	Polygon – Polygon	... overlaps ...
	Polygon – Polygon	... is attached to ...

Features that are attached to each other must share all mutually co-incident vertices. This must be applied for features of the same feature class and for features of different feature classes. Examples are given in Figure 4-3 in which the square symbols indicate start- and end-nodes. The triangle symbols indicate vertices between start- and end-nodes.

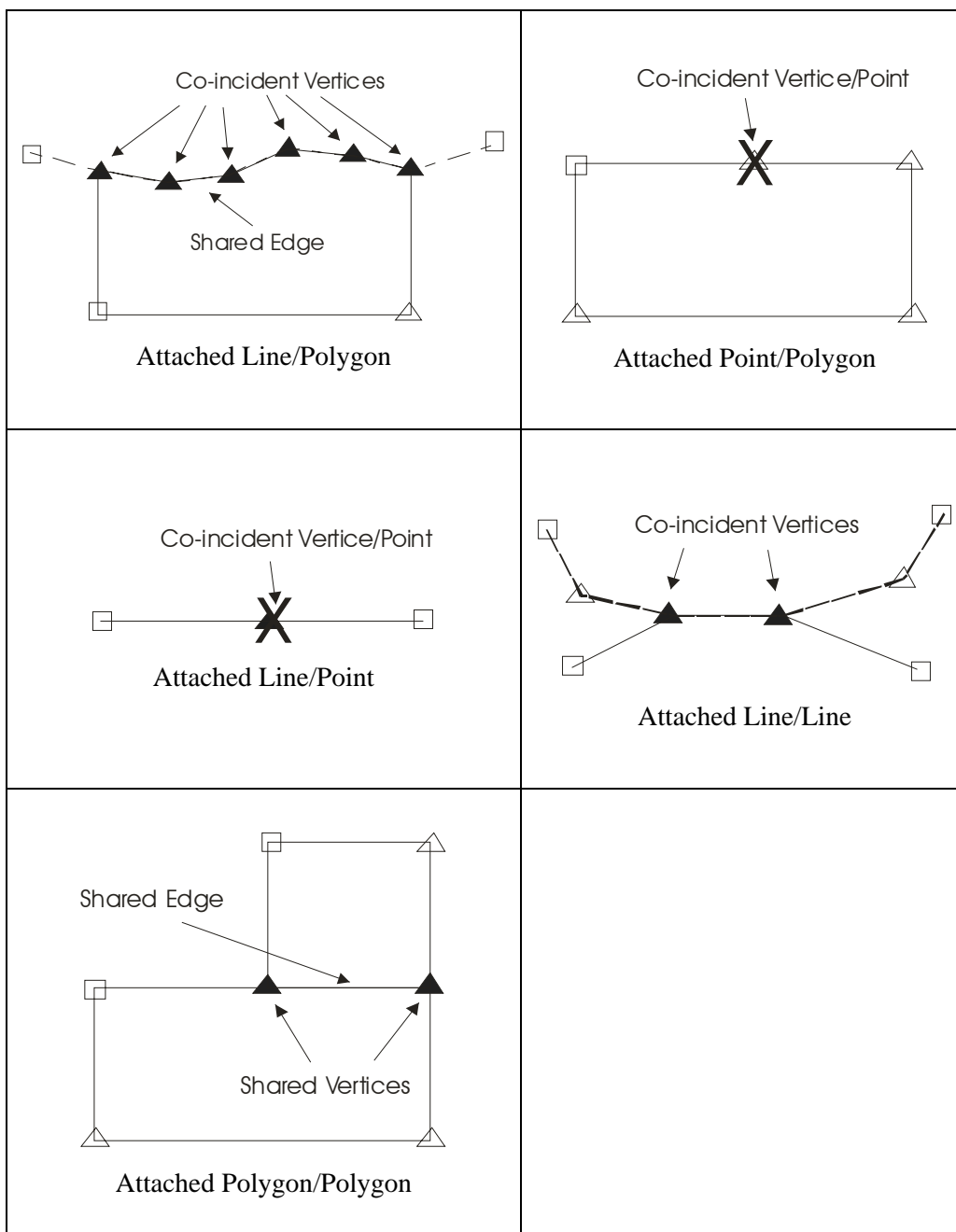


Figure 4-3. Features Attached to Each Other

Polygon features that are attached to each other and line features that are connected to each other and that have the same characteristics must be represented by a unique object if it is not specified differently in this chapter.

For connected lines (e.g. taxi-lines), the end-node of the first line and the start-node of the next line must have identical (coincident) coordinates (see Figure 4-4). This applies for features of the same feature class (e.g. TaxiwayGuidanceLines) and for features of different feature classes (e.g. TaxiGuidanceLine - RunwayExitLine).

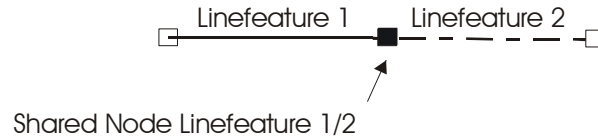


Figure 4-4. Connected Line Features

No two line features could overlap. Any line feature that intersects with a polygonal feature must include a vertex at the intersection point (Figure 4-5).

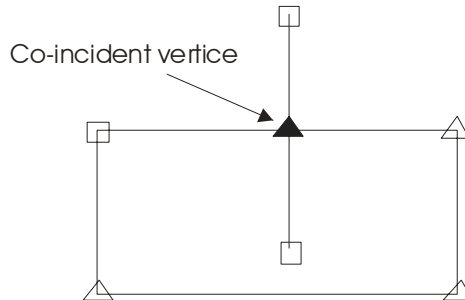


Figure 4-5. Line Feature Intersecting Polygonal Feature

Geospatial locations of the start-node and end-node of a series of lines that form a polygon must be identical (coincident). All polygons must be captured in a counter clockwise order (Figure 4-6).

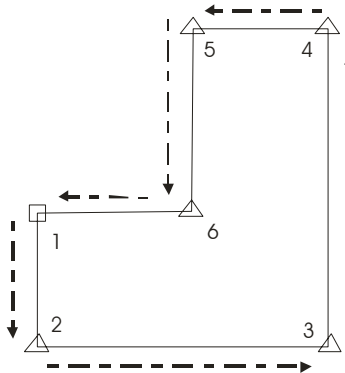


Figure 4-6. Ordering of Polygon Vertices

Polygons of the same feature class must not overlap or be contained within each other. Polygons of different feature classes must not overlap with or be contained within other polygons except for RunwayMarkings, FrequencyAreas, ConstructionAreas, TouchDownLiftOffArea, FinalApproachAndTake-offArea, Deicing Area, and Service Roads. No curves, parameterized curves, and/or polygons that overlap themselves must be used.

Table 4-3 gives an overview of the recommended spatial connections between AMDB objects. Geometrical connections are only applicable if both connected objects exist in the AMDB and if the geometrical connections are observable in the real world. Rules are included in this document if they apply to the majority of feature connections in the real world. These rules are expressed via the black cells in Table 4-3. The number in each black cell is a reference to the associated rule described further in this chapter. All potential geometrical connections are defined as equivalence relationships. Consequently, Table 4-3 is symmetrical. The feature names given in Table 4-3 are defined in Chapter 4.3.

Table 4-3. Geometrical constraints

		Black cell : geometrical connection is recommended and explicit rule is given below										White cell : geometrical connection is not recommended										Yellow cell : geometrical connection is possible without specific recommendation											
		Polygons																															
		RunwayElement	RunwayIntersection	RunwayDisplacedArea	RunwayShoulder	Stopway	RunwayMarking	TaxiwayElement	TaxiwayShoulder	FrequencyArea	ApronElement	ParkingStandArea	DeicingArea	VerticalPolygonalStructure	ConstructionArea	FinalApproachAndTakeOffArea	TouchDownLiftOffArea	ServiceRoad	Lines														
Polygons	RunwayElement																			ArrestingGearLocation	PaintedCenterline	LandAndHoldShortOperationsLocation	TaxiwayGuidanceLine	TaxiwayIntersectionMarking	TaxiwayHoldingPosition	RunwayExitLine	StandGuidanceLine	VerticalLineStructure					
	RunwayIntersection	1																															
	RunwayDisplacedArea	2																															
	RunwayShoulder	3	3	3	3																												
	Stopway	4	4	4	3																												
	RunwayMarking	5	5	5	3	5	7																										
	TaxiwayElement	6		8				15																									
	TaxiwayShoulder							16	25																								
	FrequencyArea																																
	ApronElement							17				26																					
	ParkingStandArea							18				27	33																				
	DeicingArea							19				28		36																			
	VerticalPolygonalStructure											29																					
	ConstructionArea																																
	FinalApproachAndTakeOffArea																																
	TouchDownLiftOffArea																	40															
	ServiceRoad																																
Lines	ArrestingGearLocation	10		10		10																											
	PaintedCenterline	11	11	12		12														43													
	LandAndHoldShortOperationsLocation	9																															
	TaxiwayGuidanceLine							20			30		37																				
	TaxiwayIntersectionMarking							21																									
	TaxiwayHoldingPosition							22																									
	RunwayExitLine	13		13				23																									
	StandGuidanceLine							24				31	34	38																			
Points	RunwayThreshold	14		14		14																											
	ParkingStandLocation											32	35	39																			
	VerticalPointStructure																																
	SurveyControlPoint																																
	AerodromeReferencePoint																																
	HelipadThreshold																																

The following rules for feature-specific geometrical constraints apply:

(Rule 1) A **RunwayIntersection** feature must be attached to all corresponding **RunwayElement** features.

(Rule 2) A **RunwayDisplacedArea** feature must be attached to the corresponding **RunwayElement** feature.

(Rule 3) A **RunwayShoulder** feature must be attached to the corresponding **RunwayElement** feature and/or **RunwayIntersection** feature and/or **RunwayDisplacedArea** feature and/or **Stopway** feature and/or **RunwayShoulder** feature and/or **RunwayMarking** feature.

(Rule 4) A **Stopway** feature must be attached to the corresponding **RunwayElement** feature or **RunwayIntersection** feature or **RunwayDisplacedArea** feature.

(Rule 5) A **RunwayMarking** feature must be contained in a **RunwayElement** feature and/or a **RunwayDisplacedArea** feature and/or a **Stopway** feature and/or a **RunwayIntersection** feature.

(Rule 6) A **TaxiwayElement** feature adjacent to a **RunwayElement** must be attached to the corresponding **RunwayElement** feature.

(Rule 7) A **RunwayMarking** feature which composes the runway designation (e.g. 0, 4, 6, 8, and 9 numbers) must be attached to other **RunwayMarking** features that compose the same runway designation (Figure 4-7).

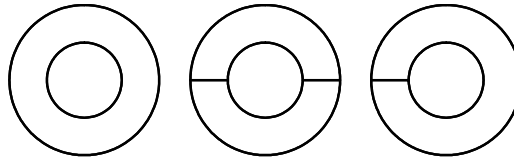


Figure 4-7. Example Geometries for “0” Runway Marking

(Rule 8) A **RunwayDisplacedArea** feature must be attached to an adjacent **TaxiwayElement** feature.

(Rule 9) A **LandAndHoldShortOperationLocation** feature must start and end at the edge of the corresponding **RunwayElement** feature.

(Rule 10) An **ArrestingGearLocation** feature must cross the corresponding **RunwayElement** feature and/or **RunwayDisplacedArea** feature and/or **Stopway** feature.

(Rule 11) A **PaintedCenterline** feature must cross all corresponding **RunwayElement** features and/or **RunwayIntersection** features.

(Rule 12) A **PaintedCenterline** feature must start/end at the edge of a corresponding **RunwayDisplacedArea** feature and/or the corresponding **Stopway** feature.

(Rule 13) A **RunwayExitline** feature must intersect the corresponding **RunwayElement** feature and/or **RunwayDisplacedArea** feature.

(Rule 14) A **RunwayThreshold** feature must be located at the edge of the corresponding **RunwayElement** feature and/or **RunwayDisplacedArea** feature and/or **Stopway** feature.

- (Rule 15) A **TaxiwayElement** feature must be attached to all corresponding **TaxiwayElement** features.
- (Rule 16) A **TaxiwayShoulder** feature must be attached to all corresponding **TaxiwayElement** features.
- (Rule 17) An **ApronElement** feature must be attached to all corresponding **TaxiwayElement** features.
- (Rule 18) A **ParkingStandArea** feature must be attached to all corresponding **TaxiwayElement** features.
- (Rule 19) A **DeicingArea** feature must be attached to all adjacent **TaxiwayElement** features.
- (Rule 20) A **TaxiwayGuidanceLine** feature must be contained in the corresponding **TaxiwayElement** feature.
- (Rule 21) A **TaxiwayIntersectionMarking** feature must intersect the corresponding **TaxiwayElement** feature.
- (Rule 22) A **TaxiwayHoldingPosition** feature must be attached to the corresponding **TaxiwayElement** feature and not intersect the corresponding **TaxiwayElement** feature.
- (Rule 23) A **RunwayExitLine** feature must intersect the corresponding **TaxiwayElement** feature.
- (Rule 24) A **StandGuidanceLine** feature must intersect the corresponding **TaxiwayElement** feature.
- (Rule 25) A **TaxiwayShoulder** feature must be attached to all corresponding **TaxiwayShoulder** features.
- (Rule 26) An **ApronElement** feature must be attached to all corresponding **ApronElement** features.
- (Rule 27) A **ParkingStandArea** feature must be attached to all corresponding **ApronElement** features.
- (Rule 28) A **DeicingArea** feature must be attached to all adjacent **ApronElement** features.
- (Rule 29) A **VerticalPolygonStructure** feature must be attached to the corresponding **ApronElement** features.
- (Rule 30) A **TaxiwayGuidanceLine** feature must be contained in the corresponding **ApronElement** features.
- (Rule 31) A **StandGuidanceLine** feature must be contained in the corresponding **ApronElement** feature.
- (Rule 32) A **ParkingStandLocation** feature must be contained in the corresponding **ApronElement** feature.
- (Rule 33) A **ParkingStandArea** feature must be attached to all corresponding **ParkingStandArea** features.
- (Rule 34) A **StandGuidanceLine** feature must intersect with the corresponding **ParkingStandArea** feature.
- (Rule 35) A **ParkingStandLocation** feature must be contained in the corresponding **ParkingStandArea** feature

- (Rule 36) A **DeicingArea** feature must be attached to all corresponding **DeicingArea** features.
- (Rule 37) A **TaxiwayGuidanceLine** feature must intersect the corresponding **DeicingArea** feature.
- (Rule 38) A **StandGuidanceLine** feature must intersect with the corresponding **DeicingArea** feature.
- (Rule 39) A **ParkingStandLocation** feature must be contained in the corresponding **DeicingArea** feature.
- (Rule 40) A **TouchDownLiftOffArea** feature must be contained in the corresponding **FinalApproachAndTake-offArea** feature.
- (Rule 41) A **HelipadThreshold** feature must be located at the edge of the corresponding **FinalApproachAndTake-offArea** feature.
- (Rule 42) A **HelipadThreshold** feature must be located at the edge of the corresponding **TouchDownLiftOffArea** feature.
- (Rule 43) An **ArrestingGearLocation** feature must cross a **PaintedCenterline** feature.
- (Rule 44) A **LandAndHoldShortOperationLocation** feature must cross a **PaintedCenterline** feature.
- (Rule 45) A **RunwayExitLine** feature must intersect a **PaintedCenterline** feature.
- (Rule 46) A **PaintedCenterline** feature must end at a **RunwayThreshold** feature.
- (Rule 47) A **TaxiwayIntersectionMarking** feature must cross a **TaxiwayGuidanceline** feature.
- (Rule 48) A **TaxiwayHoldingPosition** feature must cross a **TaxiwayGuidanceline** feature.
- (Rule 49) A **RunwayExitLine** feature must be connected to a **TaxiwayGuidanceline** feature.
- (Rule 50) A **StandGuidanceLine** feature must be connected to a **TaxiwayGuidanceline** feature.
- (Rule 51) A **TaxiwayHoldingPosition** feature must cross a **RunwayExitLine** feature.
- (Rule 52) A **StandGuidanceLine** feature must end at a **ParkingStandLocation** feature.

4.2.3.2 Attributes

4.2.3.2.1 Completeness

For each feature, all of the attributes defined in Chapter 4.3 must be provided. If a particular attribute is “null,” “unknown,” “not entered,” or “not applicable”, it must be listed as such.

4.2.3.2.2 Attribute Names

All attribute names must be constrained as follows: no duplicate names, only lower-case letters from ASCII code, and maximum eight letters.

4.2.3.2.3 Supplemental Features

Supplemental features are features that may be provided in an AMDB that are beyond the minimum set defined in this document.

For supplemental features, the following information must be provided: name, description, survey method, geometry type, and attribute list.

4.2.3.2.4 Supplemental Attributes

For a supplemental feature, the following attributes should be provided: featype, idarpt, objectid, idp, vacc, hacc, vres, hres, source, integr, and revdate. These attributes are defined in Chapter 4.3. For each attribute, a name and description should be provided.

4.2.3.2.5 Feature Attribute Functional Requirements

Functional constraints must be used to ensure connectivity between features on a functional level (e.g. runway elements linked with the corresponding runway threshold). Specific functional constraint requirements are as follows:

- Each AMDB feature must provide the identical **idarpt** (Aerodrome Reference Point) object identifier value.
- Every entity of an AMDB feature type must have an equal featype value.
- All AMDB features must be located within 20 km of the Aerodrome Reference Point (ARP).

Table 4-4 describes all functional connections that must be applied for AMDB objects. The number in the black cells references an associated rule described later in this chapter. All functional connections are defined as equivalence relationships. Consequently, Table 4-4 is symmetrical. The object identifier attributes must be encoded according to the rules of the feature catalogue.

Table 4-4. Functional constraints

[illegible]

The following rules for feature-specific functional constraints apply:

(Rule 1) Each **RunwayElement** feature's attribute **idrw** must provide the **idrw** object identifier value corresponding to the name of the real world runway.

(Rule 2) Each **RunwayIntersection** feature's attribute **idrwi** must provide an **idrwi** object identifier value that corresponds to the names of the real world intersection runways (**idrw**).

(Rule 3) Each **RunwayShoulder** feature's attribute **idrw** must provide the **idrw** object identifier value of the real world runway.

(Rule 4) Each **RunwayMarking** feature's attribute **idrw** must provide the **idrw** object identifier value of the real world runway.

(Rule 5) If the **LandAndHoldShortOperationLocation** feature protects a runway, the value of a **LandAndHoldShortOperationLocation** feature's attribute **idp** must be identical to the **idrw** object identifier value of the protected real world runway.

(Rule 6) The value of a **TaxiwayHoldingPosition** feature's attribute **idp** must be identical to the **idrw** object identifier value of the protected real world runway.

(Rule 7) Each **RunwayDisplacedArea** feature's attribute **idthr** must provide the **idthr** object identifier value of the operationally corresponding **RunwayThreshold**.

(Rule 8) Each **Stopway** feature's attribute **idthr** must provide the **idthr** object identifier value of the operationally corresponding **RunwayThreshold**.

(Rule 9) Each **TaxiwayElement** feature's attribute **idlin** must provide the **idlin** object identifier value corresponding to the name of the real world taxiway.

(Rule 10) The value of a **TaxiwayGuidanceLine** feature's attribute **idlin** must be identical to the value of the corresponding **TaxiwayElement** feature's attribute **idlin**.

(Rule 11) The value of a **TaxiwayIntersectionMarking** feature's attribute **idlin** must be identical to the value of the corresponding **TaxiwayElement** feature's attribute **idlin**.

(Rule 12) The value of a **TaxiwayHoldingPosition** feature's attribute **idlin** must be identical to the value of the corresponding **TaxiwayElement** feature's attribute **idlin**.

(Rule 13) Each **ParkingStandArea** feature's attribute **idstd** must provide an **idstd** object identifier value that holds the **idstd** object identifier values of all corresponding **ParkingStandLocations**.

(Rule 14) Each **FinalApproachAndTake-off** feature's attribute **idrw** must provide the **idrw** object identifier value of the corresponding **TouchDownAndLiftOff**.

(Rule 15) Each **FinalApproachAndTake-off** feature's attribute **idthr** must provide the **idrw** object identifier value of the corresponding **HelipadThreshold**.

(Rule 16) The value of an **ArrestingGearLocation** feature's attribute **idthr** must be identical to the value of its operationally corresponding **RunwayThresholds** feature's attribute **idthr**.

(Rule 17) For runways with thresholds at both ends, the value of a **PaintedCenterline** feature's attribute **idrwy** must be identical to the value of the corresponding real world runway. For runways with one threshold only, the value of a **PaintedCenterline** feature's attribute **idrwy** must be identical to the value of the real world runway.

(Rule 18) The value of a **LandAndHoldShortOperationLocation** feature's attribute **idthr** must be identical to the value of the operationally corresponding **RunwayThresholds** feature's attribute **idthr**.

(Rule 19) The value of a **RunwayExitLine** feature's attribute **idlin** must be identical to the value of every connecting **TaxiwayGuidanceLine** feature's attribute **idlin**, in case they are located on the same corresponding **TaxiwayElement** or if multiple adjacent **TaxiwayElements** share the same attribute's value **idlin**.

(Rule 20) The value of a **TaxiwayHoldingPosition** feature's attribute **idp** must be identical to the value of the operationally corresponding **RunwayThresholds** feature's attribute **idthr**.

(Rule 21) The value of a **RunwayExitLine** feature's attribute **idthr** must be identical to the value of the operationally corresponding **RunwayThresholds** feature's attribute **idthr**.

(Rule 22) Each **StandGuidanceLine** feature's attribute **idstd** must provide object identifier values for all corresponding **ParkingStandLocations**.

(Rule 23) The value of a **ParkingStandArea** feature's attribute **idapron** must be identical to the value of the operationally corresponding **ApronElement** feature's attribute **idapron**.

(Rule 24) The value of a **TaxiwayElement** feature's attribute **idapron** must be identical to the value of the operationally corresponding **ApronElement** feature's attribute **idapron**.

(Rule 25) The value of a **ParkingStandArea** feature's attribute **idapron** must be identical to the value of the operationally corresponding **TaxiwayElement** feature's attribute **idapron**.

(Rule 26) The value of a **DeicingArea** feature's attribute **ibase** must be identical to the value of the underlying **ApronElement** feature's attribute **idapron**.

The value of a **DeicingArea** feature's attribute **ibase** must be identical to the value of the underlying **TaxiwayElement** feature's attribute **idlin** (Rule 27).

(Rule 28) The value of a **DeicingArea** feature's attribute **ibase** must be identical to the value of the underlying **ParkingStandArea** feature's attribute **idstd**.

In some particular cases, functional connections may not be complete regarding certain real world constraints (e.g. missing paint), therefore, these connections may not be applicable and mandatory to all functions using this data.

Each **RunwayExitLine** feature's attribute **idrwy** must provide the **idrwy** object identifier value of the **PaintedCenterline** from which the **RunwayExitLine** starts.

4.2.3.3 Data Elements

For the purposes of this document, data elements have been listed by class. The seven classes are runways, helipads, taxiways, aprons, vertical structures, construction areas, and quality data. Each class requires that different objects be captured in the AMDB.

Supplemental data classes that have not been specified but may be useful to some applications include, for example, INS/VOR checkpoints, noise abatement zones, special use areas, signage, and aerodrome boundaries. AMDB features and attributes must be encoded according to the rules of the feature catalogue.

4.2.3.3.1 Runways

An overview of runway data elements is shown in the following figure:

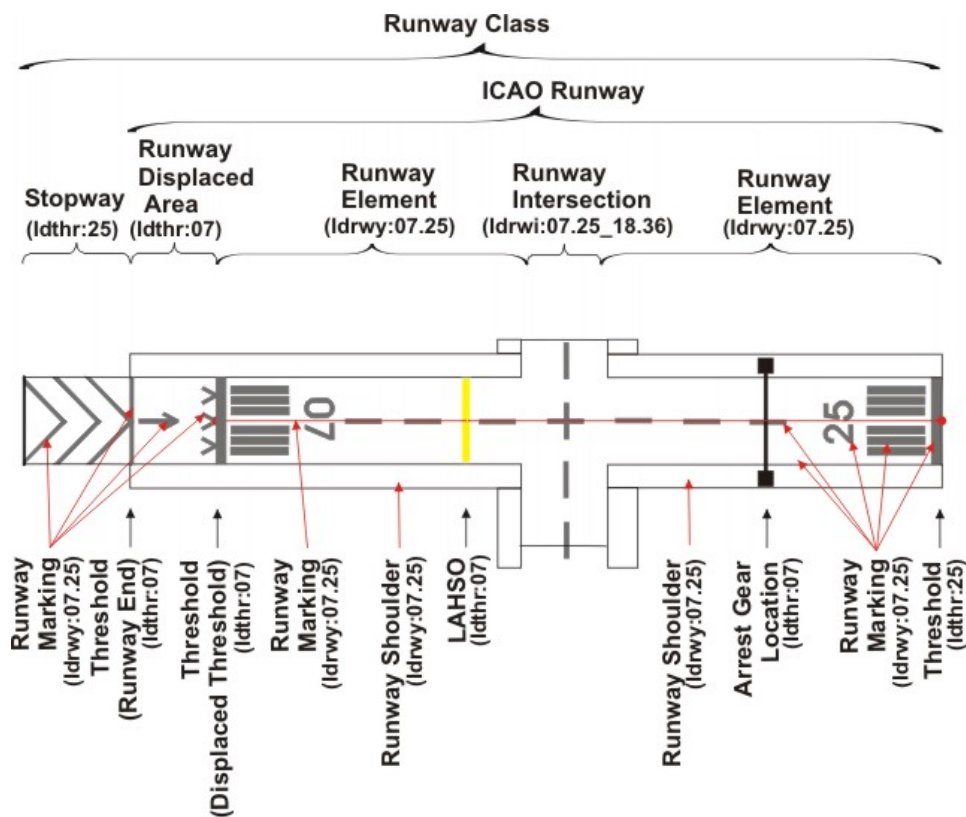


Figure 4-8. Runway Elements

4.2.3.3.1.1 Runway Elements

Definition: Part of a runway.

Description: A runway element may consist of one or more polygons not defined as other portions of the runway class (e.g. stopway)

Data Capture Rule:	All runway elements must be individual objects in the database. The runway element is delimited by the outer edge of the white runway edge painting. Runway elements must include any portion of a runway not otherwise identified as an intersection, threshold, marking, centerline, LAHSO location, arresting gear location, shoulder, stopway, displaced area, or exit line.	
Feature Name:	RunwayElement	
Geometry:	Polygon	
Attributes:		
(1)	featype	Runway feature type identifier
(2)	idarpt	Location indicator
(3)	idrwy	Object identifier
(4)	vacc	Vertical accuracy as a Linear Error Probability (LEP)
(5)	hacc	Horizontal accuracy as a Circular Error Probability (CEP)
(6)	vres	Vertical resolution of coordinates
(7)	hres	Horizontal resolution of coordinates
(8)	source	Name of entity or organization that supplied data
(9)	integr	Integrity of data in the aeronautical data processing chain from data origination process to present data manipulation process
(10)	revdate	Date of origination or of last data revision
(11)	pcn	A number expressing the bearing strength of a pavement for unrestricted operations. If multiple pcn's exist for a given feature, the lowest value (i.e. most restricted) must be provided.
(12)	width	Minimal width of a feature
(13)	length	Length of a feature
(14)	surftype	Predominant surface type

4.2.3.3.1.2 Runway Intersections

Definition:	Intersecting area shared by two or more runways.
Description:	The runway intersection feature is the common area of intersecting runways.
Data Capture Rule:	The runway intersection polygon is delimited by the outer edge of the white runway edge painting, excluding runway shoulders. When two or more runways intersect, the intersection must be kept as an individual object in the database. All runway intersections must be captured as individual objects.
Feature Name:	RunwayIntersection
Geometry:	Polygon

Attributes:

(1)	featype	Runway intersection feature type identifier
(2)	idarpt	Location indicator
(3)	idrwi	Object identifier
(4)	vacc	Vertical accuracy as a LEP
(5)	hacc	Horizontal accuracy as a CEP
(6)	vres	Vertical resolution of coordinates
(7)	hres	Horizontal resolution of coordinates
(8)	source	Name of entity or organization that supplied data
(9)	integr	Integrity of data in the aeronautical data processing chain from data origination process to present data manipulation process
(10)	revdate	Date of origination or of last data revision
(11)	pcn	A number expressing the bearing strength of a pavement for unrestricted operations. If multiple pcn's exist for a given feature, the lowest value (i.e. most restricted) must be provided.
(12)	surftype	Predominant surface type

4.2.3.3.1.3 Runway Thresholds

Definition: The beginning of that portion of the runway useable for landing.

Description: See definition: Annex 14, Volume I, Chapter 1

Data Capture Rule: All runway thresholds must be individual objects in the database. All runway information that is related to a landing direction must be attached to the corresponding threshold. The threshold points must be captured in three dimensions and located according to Doc 9674, Chapter 5.

Feature Name: RunwayThreshold

Geometry: Point

Attributes:

(1)	featype	Feature type
(2)	idarpt	Location indicator
(3)	idthr	Object identifier
(4)	status	State of feature (e.g. runway 25 closed)
(5)	vacc	Vertical accuracy as a LEP
(6)	hacc	Horizontal accuracy as a CEP

(7)	vres	Vertical resolution of coordinates
(8)	hres	Horizontal resolution of coordinates
(9)	source	Name of entity or organization that supplied data
(10)	integr	Integrity of data in the aeronautical data processing chain from data origination to present data manipulation process
(11)	revdate	Date of origination or of last data revision
(12)	tdze	Touchdown zone elevation (Annex 14, Volume I)
(13)	tdzslope	Touchdown zone longitudinal slope (slope of 1/3 of the runway length from threshold or first 3000 feet for runways longer than 9000 feet)
(14)	brngtrue	True runway bearing (Annex 14, Volume I)
(15)	brngmag	Magnetic runway bearing valid at the day of data generation
(16)	rwyslope	Runway slope
(17)	tora	Take-off run available (Annex 14, Volume I)
(18)	toda	Take-off distance available (Annex 14, Volume I)
(19)	asda	Accelerate-stop distance available. (Annex 14, Volume I)
(20)	lda	Landing distance available (Annex 14, Volume I)
(21)	papivasi	Vertical guidance lighting system available.
(22)	Cat	Type and Category of precision approach guidance system available
(23)	Ellipse	Height above/below the WGS-84 ellipsoid at the threshold position.
(24)	Geound	Geoidal undulation of threshold in reference to EGM 96
(25)	thrtype	Type of threshold (e.g. displaced)

4.2.3.3.1.4 Runway Markings

Definition: A symbol or group of symbols displayed on the surface of the runway in order to convey aeronautical information.

Description: These markings may include runway designation marking, runway centerline marking, threshold marking, traverse stripes, touchdown zone marking, and runway side stripe marking. See definition: Annex 14, Volume I.

Data Capture Rule:	The outline of markings painted on runways must be individual objects in the database. Use outer edges of contours of white markings painted on runway. The runway marking feature consists of multiple polygons forming the overall runway marking.	
Feature Name:	RunwayMarking	
Geometry:	Polygon	
Attributes:		
(1)	Featype	Feature type
(2)	idarpt	Location indicator
(3)	idrwy	Object identifier
(4)	vac	Vertical accuracy as a LEP
(5)	hacc	Horizontal accuracy as a CEP
(6)	vres	Vertical resolution of coordinates
(7)	hres	Horizontal resolution of coordinates
(8)	source	Name of entity or organization that supplied data
(9)	integr	Integrity of data in the aeronautical data processing chain from data origination process to present data manipulation process
(10)	revdate	Date of origination or of last data revision

4.2.3.3.1.5 Painted Centerlines

Definition:	Continuous line along the painted line in the center of a runway connecting the two thresholds.	
Description:		
Data Capture Rule:	All centerlines must be individual objects in the database. The centerline must provide sufficient data in all three dimensions to calculate touchdown zone slopes and runway slopes to the required accuracy. The line representing the centerline feature should be located in the center of the real-world centerline.	
Feature Name:	PaintedCenterline	
Geometry:	Line	
Attributes:		
(1)	featype	Feature type
(2)	idarpt	Location indicator
(3)	idrwy	Object Identifier

(4)	vacc	Vertical accuracy as a LEP
(5)	hacc	Horizontal accuracy as a CEP
(6)	vres	Vertical resolution of coordinates
(7)	hres	Horizontal resolution of coordinates
(8)	source	Name of entity or organization that supplied data
(9)	integr	Integrity of data in the aeronautical data processing chain from data origination process to present data manipulation process
(10)	revdate	Date of origination or of last data revision

4.2.3.3.1.6 Land and Hold Short Operations (LAHSO) Locations

Definition: Location of marking used for Land and Hold Short Operations (LAHSO).

Description: These runway operations include landing and holding short of an intersecting runway, an intersecting taxiway, or on some other designated point on a runway other than an intersecting runway or taxiway. Data Capture Rule: All LAHSO locations must be individual objects in the database. The lines must be captured along the outer edge (away from intersecting runway/taxiway) of the LAHSO line as painted on the runway or marked by other means (e.g. lighting).

Feature Name: LandAndHoldShortOperationLocation

Geometry: Line

Attributes:

(1)	featype	Feature type
(2)	idarpt	Location indicator
(3)	idthr	Object identifier
(4)	vacc	Vertical accuracy as a LEP
(5)	hacc	Horizontal accuracy as a CEP
(6)	vres	Vertical resolution of coordinates
(7)	hres	Horizontal resolution of coordinates
(8)	source	Name of entity or organization that supplied data
(9)	integr	Integrity of data in the aeronautical data processing chain from data origination process to present data manipulation process
(10)	revdate	Date of origination or of last data revision
(11)	idp	Object identifier of runway or taxiway being protected

4.2.3.3.1.7 Arresting Gear Locations

Definition: Location of the arresting gear cable across the runway.

Description: Generally consists of pendant cables supported over the runway surface by rubber “doughnuts”. Although most devices are located in the overrun areas, a few of these arresting systems have cables stretched over the operational areas near the ends of a runway.

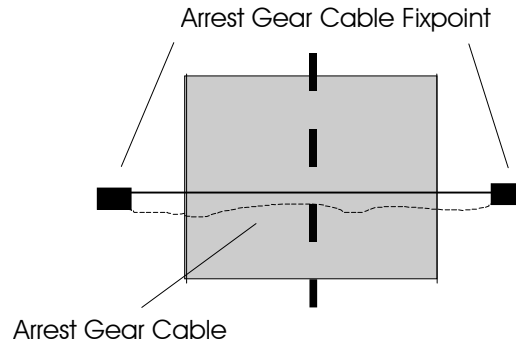


Figure 4-9. Arresting Gear Locations

Data Capture Rule: All arresting gear locations must be individual objects in the database. The line must connect the two fixed points of any arresting gear cables on each side of a runway.

Feature Name: ArrestingGearLocation

Geometry: Line

Attributes:

(1)	feattype	Feature type
(2)	idarpt	Location indicator
(3)	idthr	Object identifier
(4)	status	State of feature (e.g. non-usable)
(5)	vac	Vertical accuracy as a LEP
(6)	hacc	Horizontal accuracy as a CEP
(7)	vres	Vertical resolution of coordinates
(8)	hres	Horizontal resolution of coordinates
(9)	source	Name of entity or organization that supplied data
(10)	integr	Integrity of data in the aeronautical data processing chain from data origination process to present data manipulation process
(11)	revdate	Date of origination or of last data revision

4.2.3.3.1.8 Runway Shoulders

Definition:	An area adjacent to the edge of a runway pavement so prepared as to provide a transition between the pavement and the adjacent surface.	
Description:	See definition: Annex 14, Volume I	
Data Capture Rule:	All runway shoulders must be individual objects in the database. The runway shoulder should exclude the white runway edge painting. It typically consists of multiple polygons forming the overall shoulder on each side of the runway.	
Feature Name:	RunwayShoulder	
Geometry:	Polygon.	
Attributes:		
(1)	featype	Feature type
(2)	idarpt	Location indicator
(3)	idrwyt	Object Identifier
(4)	status	State of feature
(5)	vac	Vertical accuracy as a LEP
(6)	hacc	Horizontal accuracy as a CEP
(7)	vres	Vertical resolution of coordinates
(8)	hres	Horizontal resolution of coordinates
(9)	source	Name of entity or organization that supplied data
(10)	integr	Integrity of data in the aeronautical data processing chain from data origination process to present data manipulation process
(11)	revdate	Date of origination or of last data revision
(12)	gsurftyp	Generic surface type (e.g. concrete)

4.2.3.3.1.9 Stopways

Definition:	A defined rectangular area on the ground at the end of take-off run available prepared as a suitable area in which an aircraft can be stopped in the case of an abandoned take-off.	
Description:	See definition: Annex 14, Volume I	
Data Capture Rule:	Each stopway of a runway must be an individual object in the database. If a painted line separates a shoulder from the stopway, then the shoulder should be part of the stopway polygon. <i>Note: Stopway shoulders do not exist.</i>	
Feature Name:	Stopway	

Geometry: Polygon

Attributes:

(1)	featype	Feature type
(2)	idarpt	Location indicator
(3)	idthr	Object identifier
(4)	status	State of feature
(5)	vac	Vertical accuracy as a LEP
(6)	hacc	Horizontal accuracy as a CEP
(7)	vres	Vertical resolution of coordinates
(8)	hres	Horizontal resolution of coordinates
(9)	source	Name of entity or organization that supplied data
(10)	integr	Integrity of data in the aeronautical data processing chain from data origination process to present data manipulation process
(11)	revdate	Date of origination or of last data revision
(12)	surftype	Predominant surface type

4.2.3.3.1.10 Runway Displaced Areas

Definition: That portion of a runway between the beginning of the runway and the displaced threshold.

Description:

Data Capture Rule: Each runway displaced area must be an individual object in the database. A runway displaced area must not include the runway shoulders.

Feature Name: RunwayDisplacedArea

Geometry: Polygon

Attributes:

(1)	featype	Feature type
(2)	idarpt	Location indicator
(3)	idthr	Object identifier
(4)	status	State of feature
(5)	vac	Vertical accuracy as a LEP

(6)	hacc	Horizontal accuracy as a CEP
(7)	vres	Vertical resolution of coordinates
(8)	hres	Horizontal resolution of coordinates
(9)	source	Name of entity or organization that supplied data
(10)	integr	Integrity of data in the aeronautical data processing chain from data origination process to present data manipulation process
(11)	revdate	Date of origination or of last data revision
(12)	surftype	Predominant surface type

4.2.3.3.1.11 Runway Exit Lines

Definition: Guidance line painted on the runway exit.

Description: Painted line leading from the runway to a taxiway to exit the runway.

Data Capture Rule: Runway exit lines must be individual objects in the database and must end at the first intersection of the exit line with any other taxiway guidance line. The endpoint of the runway exit line should be the start point of a connecting taxi-line.

Feature Name: RunwayExitLine

Geometry: Line

Attributes:

(1)	featype	Feature type
(2)	idarpt	Location indicator
(3)	idlin	Object identifier
(4)	vacc	Vertical accuracy as a LEP
(5)	hacc	Horizontal accuracy as a CEP
(6)	vres	Vertical resolution of coordinates
(7)	hres	Horizontal resolution of coordinates
(8)	source	Name of entity or organization that supplied data
(9)	integr	Integrity of data in the aeronautical data processing chain from data origination process to present data manipulation process
(10)	revdate	Date of origination or of last data revision
(11)	status	State of feature

(12)	color	Color specifying the color of the taxi-line
(13)	style	Style specifying the line property of the taxi-line (e.g. dashed or solid)
(14)	direc	Directionality of corresponding taxiway

4.2.3.3.2 Helipads

As shown in Figure 4-10, helipad information consists of the final approach and take-off area (FATO), the touchdown/lift-off area (TLOF), and the helipad threshold location (Doc 9674, Chapter 5, Attachment C refers). A helipad can consist of multiple polygons.

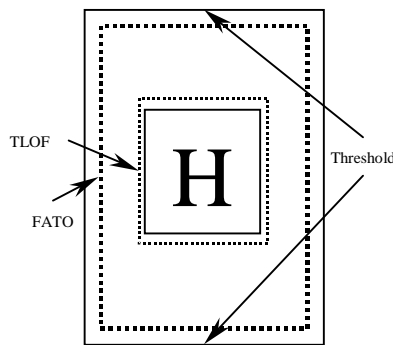


Figure 4-10. Helipad Elements

4.2.3.3.2.1 Final Approach and Take Off Areas (FATOs)

Definition: A defined area over which the final phase of the approach manoeuvre to hover or landing is completed and from which the take-off manoeuvre is commenced. Where the FATO is to be used by performance Class 1 helicopters, the defined area includes the rejected take-off area available.

Description: Annex 14, Volume II

Data Capture Rule: Final approach and take-off areas (FATO) must be included as individual objects in the database. The outer edge of the white FATO-marking should be used to represent the FATO.

Feature Name: FinalApproachAndTake-offArea

Geometry: Polygon.

Attributes:

(1)	feattype	Feature type
(2)	idarpt	Location indicator
(3)	idrwy	Object identifier
(4)	vacc	Vertical accuracy as a LEP

(5)	hacc	Horizontal accuracy as a CEP
(6)	vres	Vertical resolution of coordinates
(7)	hres	Horizontal resolution of coordinates
(8)	source	Name of entity or organization that supplied data
(9)	integr	Integrity of data in the aeronautical data processing chain from data origination process to present data manipulation process
(10)	revdate	Date of origination or of last data revision
(11)	surftype	Predominant surface type

4.2.3.3.2.2 Touchdown/Lift-off Areas (TLOFs)

Definition:	A load bearing area on which a helicopter may touchdown or lift-off.	
Description:	This is the touchdown/liftoff area of the helipad as specified by the marking.	
Data Capture Rule:	Touchdown/lift-off areas (TLOF) must be included as individual objects in the database. The outer edges of the white TLOF-markings should be used to represent the TLOF.	
Feature Name:	TouchDownLiftOffArea	
Geometry:	Polygon	
Attributes:		
(1)	featype	Feature type
(2)	idarpt	Location indicator
(3)	idrwy	Object identifier
(4)	vacc	Vertical accuracy as a LEP
(5)	hacc	Horizontal accuracy as a CEP
(6)	vres	Vertical resolution of coordinates
(7)	hres	Horizontal resolution of coordinates
(8)	source	Name of entity or organization that supplied data
(9)	integr	Integrity of data in the aeronautical data processing chain from data origination process to present data manipulation process
(10)	revdate	Date of origination or of last data revision
(11)	surftype	Predominant surface type

4.2.3.3.2.3 Helipad Thresholds

Definition: Threshold of a helipad.

Description:

Data Capture Rule: Helipad thresholds must be included as individual objects in the database.
Helipad thresholds should be surveyed in all three dimensions.

Feature Name: HelipadThreshold

Geometry: Point

Attributes:

- | | | |
|------|---------|--|
| (1) | featype | Feature type |
| (2) | idarpt | Location indicator |
| (3) | idthr | Object identifier |
| (4) | vacc | Vertical accuracy as a LEP |
| (5) | hacc | Horizontal accuracy as a CEP |
| (6) | vres | Vertical resolution of coordinates |
| (7) | hres | Horizontal resolution of coordinates |
| (8) | source | Name of entity or organization that supplied data |
| (9) | integr | Integrity of data in the aeronautical data processing chain from data origination process to present data manipulation process |
| (10) | revdate | Date of origination or of last data revision |
| (11) | status | State of feature |
| (12) | ellipse | Height below/above the WGS-84 ellipsoid |
| (13) | geound | Geoidal undulation of threshold in reference to EGM 96 |

4.2.3.3.3 Taxiways

As shown in Figure 4-11 taxiways include runway exit taxiways and apron taxiways (see definition: Annex 14, Volume I).

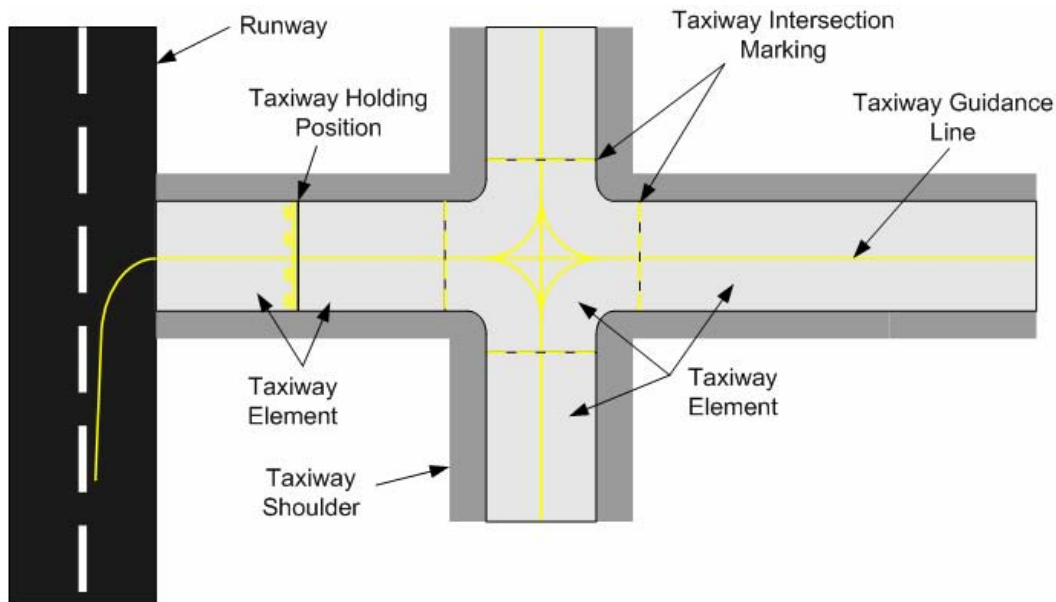


Figure 4-11. Taxiway Elements

4.2.3.3.3.1 Taxiway Elements

Definition: Part of a taxiway.

Description: Elements of a taxiway include: taxiway, apron taxiway, rapid exit taxiway, and aircraft stand taxi-lane surfaces as defined in Annex 14 Volume I.

Data Capture Rule: All taxiway elements, as well as taxiway intersections, must be included as individual objects in the database. *Note: Taxiway elements do not include taxiway shoulders and aircraft parking/stand areas.*

Each taxiway element polygon must describe the surface of a single taxiway. A single taxiway is an area identified by the same name. A single taxiway must be split in those areas where two or more taxiway guidance lines lead into each other. A separate taxiway element must be provided representing the intersection (Figure 4-12).

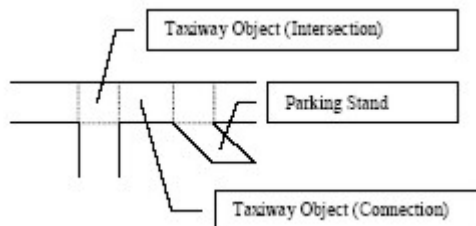


Figure 4-12. Taxiway Intersections

The taxiway element polygon should be limited by the outer side of the taxiway edge marking.

Taxiway holding positions should be coincident with the edges of two adjacent taxiway element polygons.

Taxiway intersection markings must be coincident with the edges of two adjacent taxiway element polygons if the marking is less than 10m away from the intersection. See Figure 4-13.

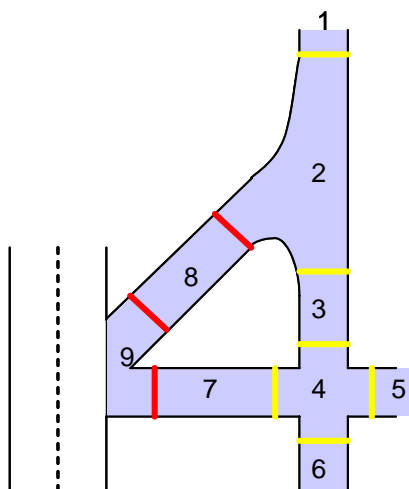


Figure 4-13. Individually Captured Taxiway Elements

Feature Name: TaxiwayElement

Geometry: Polygon

Attributes:

(1)	featype	Feature type
(2)	idarpt	Location indicator
(3)	idlin	Object identifier
(4)	vacc	Vertical accuracy as a LEP
(5)	hacc	Horizontal accuracy as a CEP
(6)	vres	Vertical resolution of coordinates
(7)	hres	Horizontal resolution of coordinates
(8)	source	Name of entity or organization that supplied data
(9)	integr	Integrity of data in the aeronautical data processing chain from data origination process to present data manipulation process
(10)	revdate	Date of origination or of last data revision
(11)	gsurftyp	Generic surface type (e.g. concrete)

(12)	bridge	Taxiway is either an underpass or an overpass
(13)	pcn	A number expressing the bearing strength of a pavement for unrestricted operations. If multiple pcn's exist for a given feature, the lowest should be used.
(14)	idapron	Name of apron. If the taxiway element is located on an apron, the name of the apron must be indicated. If the taxiway is not located on an apron, then "Not Applicable" must be indicated. See Figure 4-14.

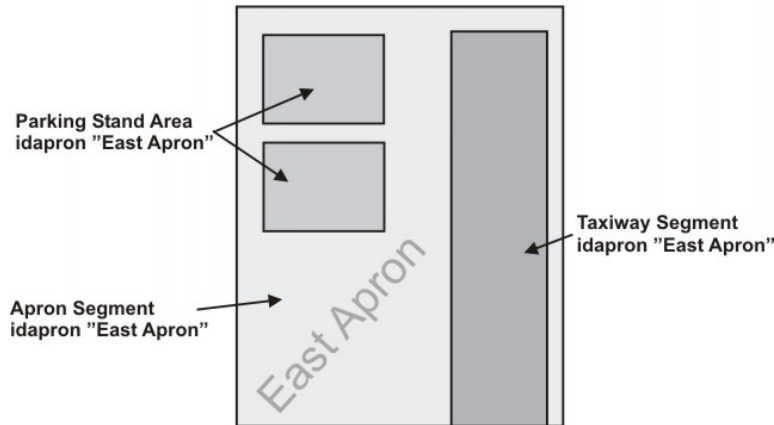


Figure 4-14 Attribute 'idapron'

4.2.3.3.2 Taxiway Shoulders

Definition:	An area adjacent to the edge of a taxiway pavement so prepared as to provide a transition between the pavement and the adjacent surface.	
Description:	Taxiway shoulders are separate from, but connected to, the taxiway edge marking. See definition: Annex 14, Volume I	
Data Capture Rule:	Taxiway shoulders must be included as individual objects in the database. The taxiway shoulder polygon should exclude the taxiway edge marking. It can consist of multiple polygons forming the overall taxiway shoulder.	
Feature Name:	TaxiwayShoulder	
Geometry:	Polygon	
Attributes:		
(1)	featype	Feature type
(2)	idarpt	Location indicator
(3)	status	State of feature
(4)	vac	Vertical accuracy as a LEP
(5)	hacc	Horizontal accuracy as a CEP
(6)	vres	Vertical resolution of coordinates

(7)	hres	Horizontal resolution of coordinates
(8)	source	Name of entity or organization that supplied data
(9)	integr	Integrity of data in the aeronautical data processing chain from data origination process to present data manipulation process
(10)	revdate	Date of origination or of last data revision
(11)	gsurftyp	Generic surface type (e.g. concrete)

4.2.3.3.3 Taxiway Guidance Lines

Definition: Guidance line painted on a taxiway.

Description: Taxiway guidance lines (taxi-lines) are referred to in Doc. 9157 as taxiway centerlines. See definition: Annex 14, Volume I, paragraph 5.2.8

Data Capture Rule: Guidance lines painted on a taxiway must be included as individual objects in the database. Each taxiway guidance taxi-line object in the database must be a continuous line sharing the start or end node of at least two connecting taxiway guidance taxi-line objects except if one or both ends represent the end of the painted taxi-line. Taxiway guidance lines must exclude exit lines and aircraft stand guidance taxi-lines.

For connecting taxi-lines, the endpoint of one of the taxi-line objects must be the starting point of the next one as shown in Figure 4-15.

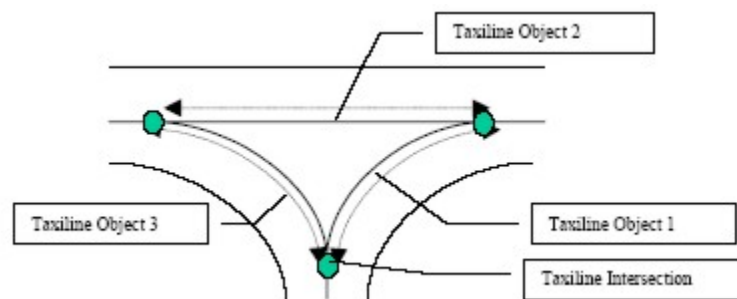


Figure 4-15. Taxiway Guidance Lines

Feature Name: TaxiwayGuidanceLine

Geometry: Line

Attributes:

(1)	feattype	Feature type
(2)	idarpt	Location indicator
(3)	idlin	Object identifier
(4)	status	State of feature
(5)	vac	Vertical accuracy as a LEP

(6)	hacc	Horizontal accuracy as a CEP
(7)	vres	Vertical resolution of coordinates
(8)	hres	Horizontal resolution of coordinates
(9)	source	Name of entity or organization that supplied
(10)	integr	Integrity of data in the aeronautical data processing chain from data origination process to present data manipulation process
(11)	revdate	Date of origination or of last data revision
(12)	wingspan	Maximum wingspan on taxiway
(13)	maxspeed	Maximum speed on taxiway
(14)	color	Color specifying the color of the taxi-line
(15)	style	Style specifying the line property of the taxiway guidance line (e.g. dashed or solid)
(16)	direc	Directionality of taxi-line (one-way or two-way)

4.2.3.3.4 Taxiway Intersection Markings

Definition: Taxiway intersection marking painted across a taxiway.

Description: See definition: Annex 14, Volume I, paragraph 5.2.10

Data Capture Rule: Taxi intersection markings must be individual objects in the database. The line must be located in the center of the painted ground marking.

Feature Name: TaxiwayIntersectionMarking

Geometry: Line

Attributes:

(1)	featype	Feature type
(2)	idarpt	Location indicator
(3)	idlin	Object Identifier
(4)	vacc	Vertical accuracy as a LEP
(5)	hacc	Horizontal accuracy as a CEP
(6)	vres	Vertical resolution of coordinates
(7)	hres	Horizontal resolution of coordinates
(8)	source	Name of entity or organization that supplied data
(9)	integr	Integrity of data in the aeronautical data processing chain from data origination process to present data manipulation process

(10)	revdate	Date of origination or of last data revision
------	---------	--

4.2.3.3.5 Taxiway Holding Positions

Definition: Taxiway holding position painted across a taxiway.

Description: See definition of Runway holding position in Annex 14, Volume I

Data Capture Rule: Taxiway holding positions must be included as individual objects in the database. The line must be located at the outer edge of the painted ground marking away from the corresponding runway.

Feature Name: TaxiwayHoldingPosition

Geometry: Line

Attributes:

(1)	featype	Feature type
(2)	idarpt	Location indicator
(3)	idlin	Object Identifier
(4)	catstop	Low Visibility Operation Category of Holding Position
(5)	status	State of feature
(6)	vac	Vertical resolution of coordinates
(7)	hacc	Horizontal accuracy as a CEP
(8)	vres	Vertical resolution of coordinates
(9)	hres	Horizontal resolution of coordinates
(10)	source	Name of entity or organization that supplied
(11)	integr	Integrity of data in the aeronautical data processing chain from data origination process to present data manipulation process
(12)	revdate	Date of origination or of last data revision
(13)	idp	Object identifier of runway or taxiway being protected

4.2.3.3.6 Frequency Areas

Definition: Designated part of a surface movement area where a specific frequency is required by air traffic control or ground control.

Description: One or more polygons that represent the region in which a specific frequency is to be used.

Data Capture Rule: Polygons representing designated areas on the surface where a specific frequency is required by ATC or ground control must be individual objects in the database. If there is only one frequency area for the aerodrome, the polygon must cover the total aerodrome area as defined in Chapter 4.2.

Feature Name FrequencyArea

Geometry: Polygon

Attributes:

(1)	featype	Feature type
(2)	idarpt	Location indicator
(3)	hacc	Horizontal accuracy as a CEP
(4)	hres	Horizontal resolution of coordinates
(5)	source	Name of entity or organization that supplied data
(6)	integr	Integrity of data in the aeronautical data processing chain from data origination process to present data manipulation process
(7)	revdate	Date of origination or of last data revision
(8)	frq	Primary frequency used on frequency area
(9)	station	Service or station assigned to primary frequency (e.g. ATC Tower, Ground Control)

4.2.3.3.4 Aprons

The Apron as defined in Annex 14, Volume I is an aggregate of the features; Apron Element, Parking Stand Area, and those Taxiway Elements that are located within the defined Apron Area. See Figure 4-16.

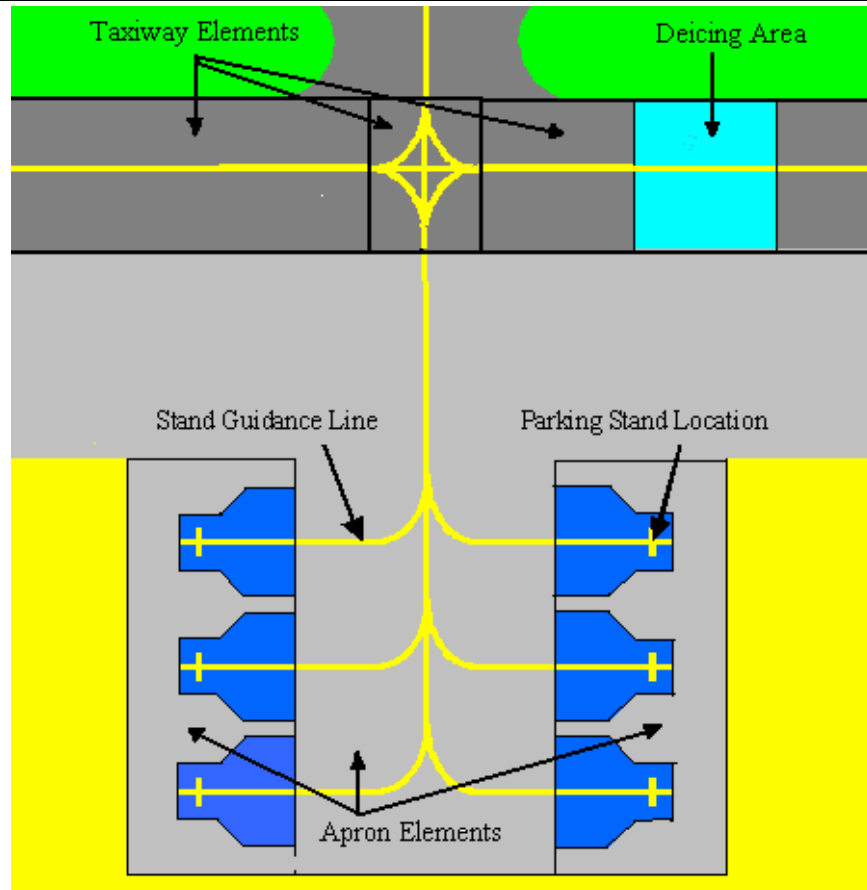


Figure 4-16. Aprons

4.2.3.3.4.1 Apron Elements

Definition: The remaining parts of a defined apron area that are not covered by Parking Stand Area features or Taxiway Element features.

Description: The apron may consist of multiple apron elements.

Data Capture Rule: Aircraft accessible apron areas that are not aircraft stands, aircraft stand taxi-lanes, or apron taxiways must be individual objects in the database. This includes turn-around areas near the end of runways and fillets designed to accommodate wide turns. See Figure 4-17.

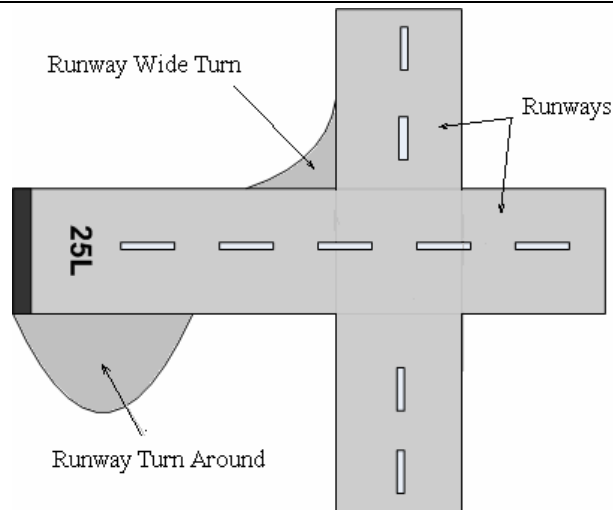


Figure 4-17. Runway Turn-Around Areas and Wide Turns

Feature Name:	ApronElement	
Geometry:	Polygon	
Attributes:		
(1)	featype	Feature type
(2)	idarpt	Location indicator
(3)	status	State of feature
(4)	vac	Vertical accuracy as a LEP
(5)	hacc	Horizontal accuracy as a CEP
(6)	vres	Vertical resolution of coordinates
(7)	hres	Horizontal resolution of coordinates
(8)	source	Name of entity or organization that supplied data
(9)	integr	Integrity of data in the aeronautical data processing chain from data origination process to present data manipulation process
(10)	revdate	Date of origination or of last data revision
(11)	pcn	A number expressing the bearing strength of a pavement for unrestricted operations. If multiple pcn's exist for a given feature, the lowest should be used.
(12)	gsurftyp	Generic surface type (e.g. concrete)
(13)	idapron	Name of apron

4.2.3.3.4.2 Stand Guidance Lines

Definition:	Guidance line on a designated area on an apron intended to be used for parking an aircraft.	
Description:	All painted taxi-lines covering a parking stand area are regarded as stand guidance lines. There may be several stand guidance taxi-lines leading to an aircraft stand to accommodate different aircraft types.	
Data Capture Rule:	All stand guidance lines must be individual objects in the database. To ensure connectivity, the start point of a stand guidance taxi-line must be the endpoint of the connecting taxiway guidance line, if applicable.	
Feature Name:	StandGuidanceLine	
Geometry:	Line	
Attributes:		
(1)	featype	Feature type
(2)	idarpt	Location indicator
(3)	idstd	Object identifier
(4)	vac	Vertical accuracy as a LEP
(5)	hacc	Horizontal accuracy as a CEP
(6)	vres	Vertical resolution of coordinates
(7)	hres	Horizontal resolution of coordinates
(8)	source	Name of entity or organization that supplied
(9)	integr	Integrity of data in the aeronautical data processing chain from data origination process to present data manipulation process
(10)	revdate	Date of origination or of last data revision
(11)	color	Color specifying the color of the stand guidance line
(12)	style	Style specifying the line property of the stand guidance line (e.g. dashed or solid)
(13)	direc	Directionality of stand guidance line
(14)	wingspan	Maximum wingspan on stand
(15)	status	State of feature

4.2.3.3.4.3 Parking Stand Locations

Definition: Location of an aircraft stand.

Description: As shown in Figure 4-18, a single parking stand location may accommodate different aircraft types (e.g. for B-747, A-340). In addition, there may be multiple parking stand locations within one parking stand area.

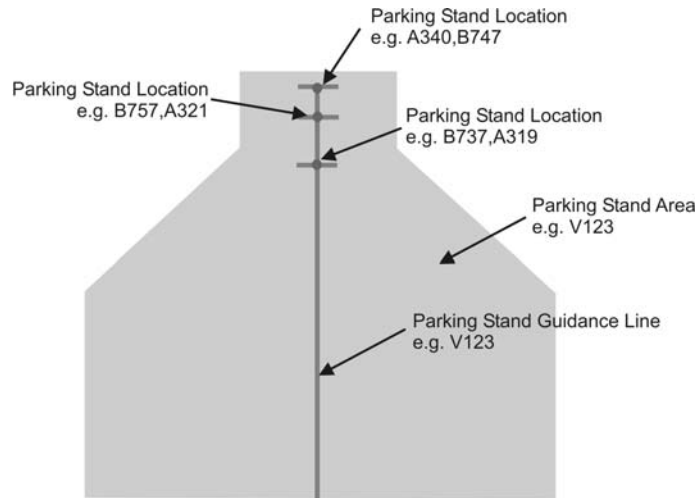


Figure 4-18. Parking Stand Locations

Data Capture Rule: Painted parking stand locations on the stand guidance line must be individual objects in the database. The parking stand location must be located on the Stand guidance line at the location indicating the position to stop for a specific aircraft type.

Feature Name: ParkingStandLocation

Geometry: Point

Attributes:

(1)	featype	Feature type
(2)	idarpt	Location indicator
(3)	idstd	Object identifier
(4)	vacc	Vertical accuracy as a LEP
(5)	hacc	Horizontal accuracy as a CEP
(6)	vres	Vertical resolution of coordinates
(7)	hres	Horizontal resolution of coordinates
(8)	source	Name of entity or organization that supplied data
(9)	integr	Integrity of data in the aeronautical data processing chain from data origination process to present data manipulation process

(10)	revdate	Date of origination or of last data revision
(11)	acn	Park stand location's feasibility for specific aircraft type according to Aircraft Classification Number (ACN)

4.2.3.3.4.4 Parking Stand Areas

Definition: A designated area on an apron intended to be used for parking an aircraft.

Description: Parking Stand Areas are operational areas near parking stands locations denoted by painted markings.

Data Capture Rule: All Parking Stand Areas must be individual objects in the database. If marked, a parking stand area polygon must be captured that coincides with the painted markings. If not marked, a polygon must be captured that considers published restrictions (e.g. wingspan limits).

Feature Name: ParkingStandArea

Geometry: Polygon

Attributes:

(1)	featype	Feature type
(2)	idarpt	Location indicator
(3)	idstd	Object identifier
(4)	vacc	Vertical accuracy as a LEP
(5)	hacc	Horizontal accuracy as a CEP
(6)	vres	Vertical resolution of coordinates
(7)	hres	Horizontal resolution of coordinates
(8)	source	Name of entity or organization that supplied
(9)	integr	Integrity of data in the aeronautical data processing chain from data origination process to present data manipulation process
(10)	revdate	Date of origination or of last data revision
(11)	pcn	A number expressing the bearing strength of a pavement for unrestricted operations. If multiple pcn's exist for a given feature, the lowest should be used.
(12)	gsurftyp	Generic surface type (e.g. concrete)
(13)	jetway	Availability of jetway
(14)	fuel	Types of fuel available
(15)	towing	Availability of towing service
(16)	docking	Availability of docking station system

- | | | |
|------|----------|------------------------------|
| (17) | gndpower | Availability of ground power |
| (18) | idapron | Name of underlying apron. |

4.2.3.3.4.5 De-icing Areas

Definition: An area comprising an inner area for the parking of an aeroplane to receive de-icing/anti-icing treatment and an outer area for the manoeuvring of two or more mobile de-icing/anti-icing equipment.

Description: See definition: Annex 14, Volume I

The de-icing area feature polygon contains the marked de-icing area on the apron surface.

Data Capture Rule: Designated aircraft de-icing areas must be individual objects in the database.

Feature Name: DeicingArea

Geometry: Polygon

Attributes:

- | | | |
|------|----------|---|
| (1) | featype | Feature type |
| (2) | idarpt | Location indicator |
| (3) | status | State of feature |
| (4) | vac | Vertical accuracy as a LEP |
| (5) | hacc | Horizontal accuracy as a CEP |
| (6) | vres | Vertical resolution of coordinates |
| (7) | hres | Horizontal resolution of coordinates |
| (8) | source | Name of entity or organization that supplied |
| (9) | integr | Integrity of data in the aeronautical data processing chain from data origination process to present data manipulation process |
| (10) | revdate | Date of origination or of last data revision |
| (11) | gsurftyp | Generic surface type (e.g. concrete) |
| (12) | idbase | Identifier of underlying Taxiway Element (idlin), Parking Stand Area (idstd), or Apron Element (idapron). If the de-icing area overlaps another feature, this must be indicated. If the de-icing area does not overlap another feature, then "No overlap" must be indicated. See Figure 4-19. |
| (13) | ident | Name of De-icing Area. See Figure 4-19. |

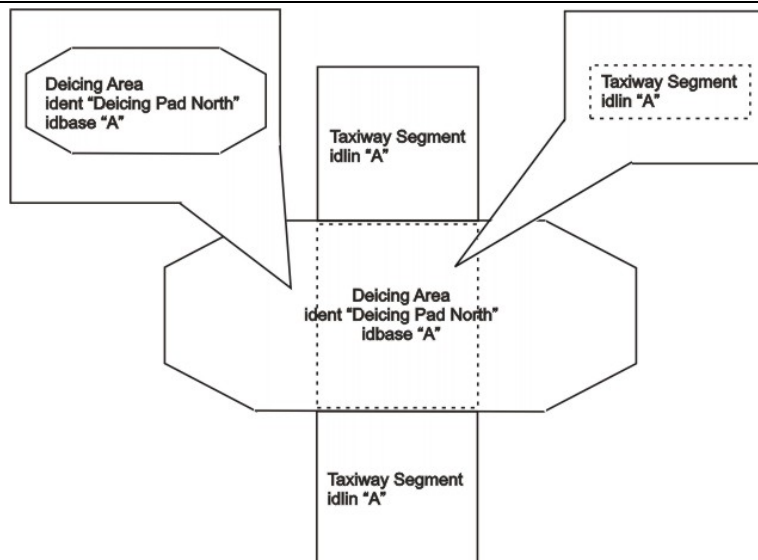


Figure 4-19. Attributes idbase and ident

4.2.3.3.4.6 Service Roads

Definition:	Part of aerodrome surface used by service vehicles.
Description:	A Service Road may consist of one or more polygons. Service roads can exist both inside and outside of the aerodrome movement area.
Data Capture Rule:	<p>Those parts of service roads that are located within an area that extends from the edge(s) of the runway(s) to 90m distance measured from the runway centerline(s) and for all other parts of the aerodrome movement area(s), 50m distance from the edge(s) of the defined area(s) must be captured.</p> <p>The capture of service roads outside the regions described above (including in the movement area) and inside the aerodrome boundary is optional.</p> <p>In case the user chooses to capture the optional Service Roads within the movement area, the overlapping area must be captured as a unique element to both classes. Both polygons must be of identical shape. See Figure 4-20.</p>

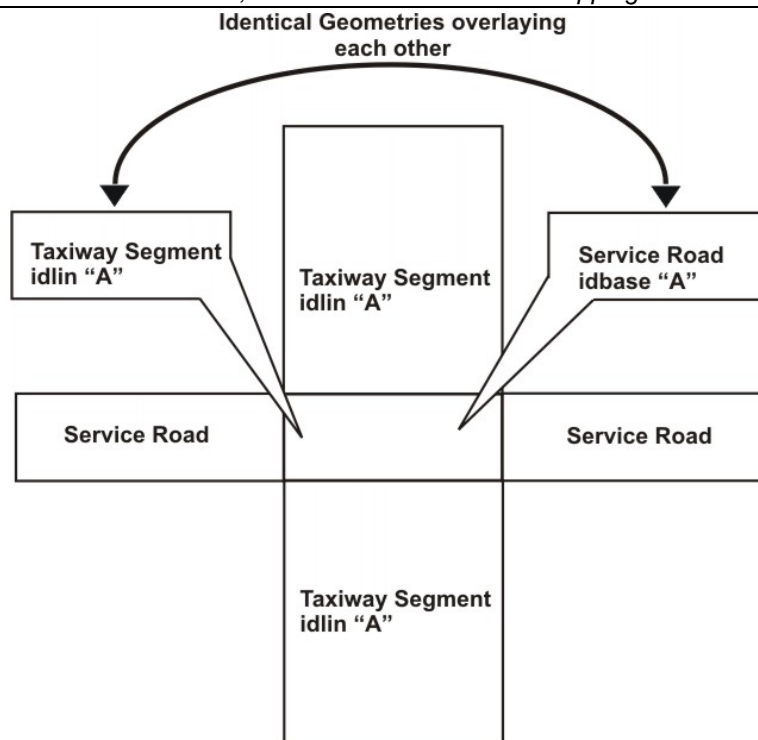


Figure 4-20. Service roads within the movement area

Feature Name: ServiceRoad

Geometry: Polygon

Attributes:

(1)	featype	Feature type
(2)	idarpt	Location indicator
(3)	vacc	Vertical accuracy as a LEP
(4)	hacc	Horizontal accuracy as a CEP
(5)	vres	Vertical resolution of coordinates
(6)	hres	Horizontal resolution of coordinates
(7)	source	Name of entity or organization that supplied data
(8)	integr	Integrity of data in the aeronautical data processing chain from data origination process to present data manipulation process
(9)	revdate	Date of origination or of last data revision
(10)	surftype	Predominant surface type
(11)	featbase	Identification of the feature type affected by the road. If the service road overlaps another feature, this must be indicated. If

the service road does not overlap another feature, then “No overlap” must be indicated.

- | | | |
|------|--------|--|
| (12) | idbase | Identifier of underlying Taxiway Element (idlin), Parking Stand Area (idstd), or Apron element (idapron). If the service road overlaps another feature, this must be indicated. If the service road does not overlap another feature, then “No overlap” must be indicated. |
|------|--------|--|

4.2.3.3.4.7 Aerodrome Reference Points

Definition: The designated geographical location of an aerodrome.

Description: See Definition: Annex 14, Volume I

Data Capture Rule: The designated geographic location of an aerodrome as published in the AIP must be an individual object in the database.

Feature Name: AerodromeReferencePoint

Geometry: Point

Attributes:

- | | | |
|------|---------|--|
| (1) | featype | Feature type |
| (2) | idarpt | Location indicator |
| (3) | iata | IATA aerodrome code |
| (4) | name | Aerodrome name |
| (5) | vacc | Vertical accuracy as a LEP |
| (6) | hacc | Horizontal accuracy as a CEP |
| (7) | vres | Vertical resolution of coordinates |
| (8) | hres | Horizontal resolution of coordinates |
| (9) | source | Name of entity or organization that supplied |
| (10) | integr | Integrity of data in the aeronautical data processing chain from data origination process to present data manipulation process |
| (11) | revdate | Date of origination or of last data revision |

4.2.3.3.5 Vertical Structures

Vertical structures include point, line, and polygon structures. Point structures have a radius indicating any associated structures such as guy-wires. See Figure 4-21.

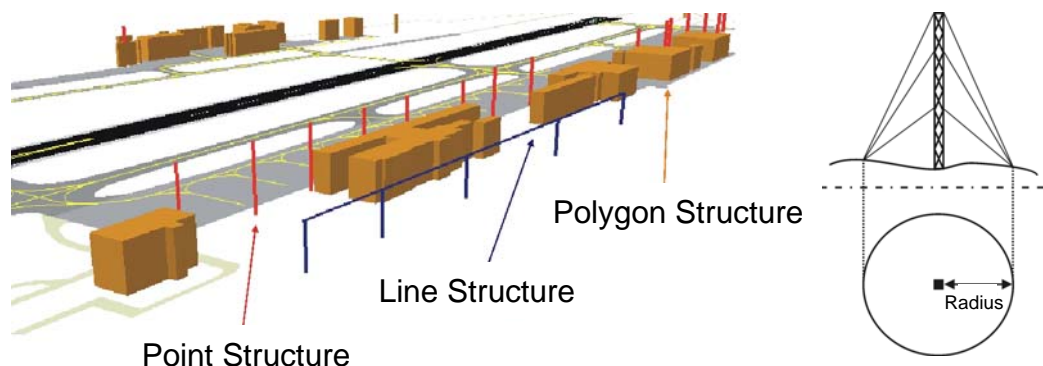


Figure 4-21. Vertical structures

4.2.3.3.5.1 Vertical Polygonal Structures

Definition: Polygonal structure of a defined vertical extent that is located within an area that extends from the edge(s) of the runway(s) to 90m distance measured from the runway centerline(s) and for all other parts of the aerodrome movement area(s), 50m distance measured from the edge(s) of the defined area(s).

Description: All polygonal structures (e.g. buildings) whose maximum height exceeds the defined vertical limit.

Data Capture Rule: All Vertical Polygon Structures must be individual objects in the database. In the horizontal plane, a structure that has a complex real world shape may be decomposed into multiple polygons. In the vertical plane, all polygons should have a height attribute indicating the highest point of the corresponding real-world object.

Feature Name: VerticalPolygonalStructure

Geometry: Polygon

Attributes:

(1)	featype	Feature type
(2)	idarpt	Location indicator
(3)	plysttyp	Polygonal structure type
(4)	vacc	Vertical accuracy as a LEP
(5)	hacc	Horizontal accuracy as a CEP
(6)	vres	Vertical resolution of coordinates
(7)	hres	Horizontal resolution of coordinates

(8)	source	Name of entity or organization that supplied data
(9)	integr	Integrity of data in the aeronautical data processing chain from data origination process to present data manipulation process
(10)	revdate	Date of origination or of last data revision
(11)	height	Maximum height of top of vertical structure
(12)	elev	Maximum elevation of top of vertical structure (Orthometric height)
(13)	material	Predominant surface material of the vertical structure
(14)	ident	Name/identifier of vertical polygon structure if specific name is given.

4.2.3.3.5.2 Vertical Point Structures

Definition: Point structure of a defined vertical extent that is located within an area that extends from the edge(s) of the runway(s) to 90m distance measured from the runway centerline(s) and for all other parts of the aerodrome movement area(s), 50m distance measured from the edge(s) of the defined area(s).

Description: All point structures (e.g. radio towers) whose maximum height exceeds the defined vertical limit.

Data Capture Rule: All Vertical Point Structures must be individual objects in the database. In the horizontal plane, the vertical point object should be located in the center of the corresponding real-world object. In the vertical plane, it should be located on the highest point of the real-world object.

Feature Name: VerticalPointStructure

Geometry: Point

Attributes:

(1)	featype	Feature type
(2)	idarpt	Location indicator
(3)	pntsttyp	Vertical Point Object feature type identifier
(4)	vacc	Vertical accuracy as a LEP
(5)	hacc	Horizontal accuracy as a CEP
(6)	vres	Vertical resolution of coordinates
(7)	hres	Horizontal resolution of coordinates
(8)	source	Name of entity or organization that supplied data
(9)	integr	Integrity of data in the aeronautical data processing chain from data origination process to present data manipulation process

(10)	revdate	Date of origination or of last data revision
(11)	marking	Obstacle marking in conformance with Annex 14, Volume I, paragraph 6.2
(12)	lighting	Obstacle lighting in conformance with Annex 14, Volume I, paragraph 6.2
(13)	radius	Radius of circle around center of obstacle including body of obstacle and associated structures such as guy-wires
(14)	height	Maximum height of top of vertical structure
(15)	elev	Maximum elevation of top of vertical structure (Orthometric elevation)
(16)	material	Predominant surface material of the vertical structure

4.2.3.3.5.3 Vertical Line Structures

Definition: Line structure of a defined vertical extent that is located within an area that extends from the edge(s) of the runway(s) to 90m distance measured from the runway centerline(s) and for all other parts of the aerodrome movement area(s), 50m distance measured from the edge(s) of the defined area(s).

Description: All line structures (e.g. power lines) whose maximum height exceeds the defined vertical limit.

Data Capture Rule: All Vertical Line Structures must be individual objects in the database. In the horizontal plane, the vertical line object should be located in the center of the corresponding real-world object. In the vertical plane, it should be located on the highest point of the real-world object.

Feature Name: VerticalLineStructure

Geometry: Line

Attributes:

(1)	featype	Feature type
(2)	idarpt	Location indicator
(3)	linsttyp	Vertical Line Object feature type identifier
(4)	vacc	Vertical accuracy as a LEP
(5)	hacc	Horizontal accuracy as a CEP
(6)	vres	Vertical resolution of coordinates
(7)	hres	Horizontal resolution of coordinates
(8)	source	Name of entity or organization that supplied data

(9)	integr	Integrity of data in the aeronautical data processing chain from data origination process to present data manipulation process
(10)	revdate	Date of origination or of last data revision
(11)	marking	Obstacle marking in conformance with Annex 14, Volume I, paragraph 6.2
(12)	lighting	Obstacle lighting in conformance with Annex 14, Volume I, paragraph 6.2
(13)	height	Maximum height of top of vertical structure
(14)	elev	Maximum elevation of top of vertical structure (Orthometric height)
(15)	material	Predominant surface material of the vertical structure

4.2.3.3.6 Construction Areas

Definition: Part of a movement area under construction.

Description: The construction area feature is that part of the aircraft surface movement area under construction, including runways, taxiways, apron, aircraft parking stands, and de-icing areas.

Data Capture Rule: Aircraft movement areas under construction must be individual objects in the database.

Feature Name: ConstructionArea

Geometry: Polygon

Attributes:

(1)	featype	Feature type
(2)	idarpt	Location indicator
(3)	vacc	Vertical accuracy as a LEP
(4)	hacc	Horizontal accuracy as a CEP
(5)	vres	Vertical resolution of coordinates
(6)	hres	Horizontal resolution of coordinates
(7)	source	Name of entity or organization that supplied data
(8)	integr	Integrity of data in the aeronautical data processing chain from data origination process to present data manipulation process
(9)	revdate	Date of origination or of last data revision
(10)	postdate	Planned construction start date
(11)	pendate	Planned construction end date

(12) piocdate Planned initial operational date (inc commission date)

4.2.3.3.7 Quality Data

The following data elements are needed to support quality assurance.

4.2.3.3.7.1 Survey Control Points

Definition: A monumented survey control point.

Description: See Definition: Doc 9674, Chapter 5.2.5.

Data Capture Rule: Locations of monumented survey control points at the aerodrome must be individual objects in the database. The marked position of a survey control point must be captured.

Feature Name: SurveyControlPoint

Geometry: Point

Attributes:

- | | | |
|------|----------|---|
| (1) | featype | Feature type |
| (2) | idarpt | Location indicator |
| (3) | idsurv | Object identifier |
| (4) | vacc | Vertical accuracy as a LEP |
| (5) | hacc | Horizontal accuracy as a CEP |
| (6) | vres | Vertical resolution of coordinates |
| (7) | hres | Horizontal resolution of coordinates |
| (8) | source | Name of entity or organization that supplied data |
| (9) | integr | Integrity of data in the aeronautical data processing chain from data origination process to present data manipulation process |
| (10) | revdate | Date of origination or of last data revision |
| (11) | coord | Published reference coordinates (x/y/z or lat/long/elevation) of survey point as provided by authorized survey institution. This information is expressed in the complete resolution of the original surveyed values. |
| (12) | hdatum | Full name of horizontal datum of reference coordinates |
| (13) | vdatum | Name of vertical datum of reference coordinates |
| (14) | spheroid | Spheroid of reference coordinate |
| (15) | project | Full name of projection of reference coordinates |

4.2.4 AMDB Quality

4.2.4.1 Accuracy

Accuracy requirements are specified according to three categories: *Fine*, *Medium*, and *Coarse*. Aerodrome mapping data accuracy must meet a confidence level of 95% for *Fine* and 90% for *Medium* or *Coarse* quality categories. Further, there may be data elements at specific aerodromes that are deemed critical in terms of operational safety by system designers. For these elements, sufficient validation may be necessary to ensure that the stated accuracy is not only at the required confidence level, but also bounded to a prescribed worst-case inaccuracy. Aerodrome mapping geometry data must meet the accuracy requirements listed in Tables 4-5 through 4-8. The accuracy requirement listed for a particular data element applies to all position coordinates that constitute that data element.

In order to bound the error for certain elements, an additional accuracy value has been defined. The *Max Error* column of Tables 4-5 through 4-8 refers to maximum acceptable error. Most of the Max Error numbers represent approximately a six standard deviation value for a normal distribution. This value must not be exceeded for the elements specified. This limit must be applied only to *Fine* category data.

Positional accuracies are relative to a positional datum, i.e. the WGS-84 reference network at the aerodrome.

For any data element that requires multiple vertices, the number of vertices must be sufficient to maintain the required horizontal and vertical accuracy as well as to distinguish any points where multiple elements intersect.

4.2.4.2 Resolution

Resolution must be sufficient to guarantee both the horizontal and the vertical accuracy requirements listed in Tables 4-5 through 4-8. These represent the minimum resolution required. The definition for resolution must be used with respect to Tables 4-5 through 4-8.

4.2.4.3 Integrity

Integrity classification is as follows:

- (1) Critical data – there is a high probability when using corrupted critical data that the continued safe operation of an aircraft would be severely at risk with potential for catastrophe. Required level of data integrity is 10^{-8} or better.
- (2) Essential data – there is a low probability when using corrupted essential data that the continued safe operation of an aircraft would be severely at risk with potential for catastrophe. Required level of data integrity is 10^{-5} or better.
- (3) Routine data – there is a very low probability when using corrupted routine data that the continued safe operation of an aircraft would be severely at risk with the potential for catastrophe. Required level of data integrity is 10^{-3} or better.

Data originators and integrators must ensure that the integrity of aerodrome data is maintained throughout the data process from survey/origin to the end user.

Because required data integrity depends to a large degree on the application of that data (i.e. how it is used) and a detailed Functional Hazards Analysis, required integrity is not listed for each data element. However, for these elements, one of the above integrity categories must be used.

For those data elements that are already required to support air navigation, integrity requirements from those documents must be used and are re-stated in Tables 4-5 through 4-8.

4.2.4.4 Numerical Requirements

Tables 4-5 through 4-8 list data quality requirements for three categories of AMDB data: *Coarse*, *Medium*, and *Fine*.

Coarse data requirements would be the minimum acceptable data quality. Coarse quality data may support only a few of the applications described in Appendix A for a given aerodrome such as electronic charting. This data would generally support criteria for VFR and special-night VFR (helicopter) operations, primarily at general aviation (GA) uncontrolled aerodromes. It is expected that data meeting coarse requirements may be obtained from a single source (e.g. imagery or CAD drawings).

Medium data requirements would support most of the aviation applications described in Appendix A for a given aerodrome including the cockpit display of traffic information (CDTI). This data may support non-precision approach capability (e.g. VOR, NDB, and GNSS approaches). Medium data requirements may be met using imagery from commercial space systems or aircraft without ground control utilizing overlapping imagery; and/or through photogrammetric analysis utilizing a stereoscopic model.

Fine data requirements would support all aviation applications described in Appendix A for a given aerodrome including low visibility surface navigation. This data would support all-weather flight operations including conditions when Category I, II, or III precision approaches are being flown. The most stringent approach criteria at the aerodrome will generally establish a need for Fine survey data. Acquiring this class of data would require ground control points (surveys) and the use of photogrammetric techniques in conjunction with imagery.

The Data Derivation column in Tables 4-5 through 4-8 refers to either Surveyed (S), Calculated (C), or *as charted*. If available, a surveyed value must be used instead of a calculated or *as charted* value.

In Tables 4-5 through 4-8, the three columns under *Fine*, *Medium*, and *Coarse*, list requirements for accuracy (A), resolution (R), and integrity (I), respectively. As stated previously, integrity requirements, either critical (C), essential (E), or routine (R), are listed only for those elements already required for air navigation.

Table 4-5. Horizontal data quality requirements
(All values in meters; NS denotes not specified)

Data Element	Data Derivation	Fine			Medium			Coarse			Max Error
		A	R	I	A	R	I	A	R	I	
Runway element	S	1	0.1	C	5	0.1	-	30	1	-	-
Runway intersection	S	1	0.1	C	5	0.1	-	30	1	-	-
Runway threshold	S	1	0.1	C	5	0.1	-	NS	NS	-	3
Painted centerline	S	0.5	0.01	C	5	0.1	-	NS	NS	-	2
LAHSO	S	1	0.1	R	5	0.1	-	NS	NS	-	3
Arresting gear location	S	1	0.1	-	5	0.1	-	30	1	-	-
Runway shoulder	S	1	0.1	-	5	0.1	-	30	1	-	-
Stopway	S	1	0.1	-	5	0.1	-	30	1	-	-
Runway displaced area	S	1	0.1	C	5	0.1	-	30	1	-	-
Runway marking	as charted	NS	NS	-	NS	NS	-	NS	NS	-	-
FATO	S	1	0.1	C	5	0.1	-	5	0.1	-	-
TLOF	S	1	0.1	C	5	0.1	-	5	0.1	-	-
Helipad threshold	S	1	0.1	C	5	0.1	-	NS	NS	-	-
Taxiway element	S	1	0.1	-	5	0.1	-	5	0.1	-	-
Taxiway shoulder	S	1	0.1	-	5	0.1	-	5	0.1	-	-
Taxiway guidance line	S	0.5	0.01	C	5	0.1	-	NS	NS	-	2
Taxiway intersection marking	S	0.5	0.01	C	5	0.1	-	NS	NS	-	-
Taxiway holding position	S	1	0.1	-	5	0.1	-	NS	NS	-	3
Runway exit line	S	0.5	0.01	C	5	0.1	-	NS	NS	-	2
Frequency area	C	NS	NS	-	NS	NS	-	NS	NS	-	-
Apron	S	1	0.1	-	5	0.1	-	30	1	-	-
Stand guidance line	S	0.5	0.01	E	5	0.1	-	NS	NS	-	2
Parking stand location	S	0.5	0.01	E	5	0.1	-	30	1	-	2
Parking stand area	C	1	0.1	-	5	0.1	-	30	1	-	-
Deicing area	S	1	0.1	-	5	0.1	-	30	1	-	-
Vertical polygonal objects	S	0.5	0.1	E	5	0.1	-	30	1	-	-
Vertical point objects	S	0.5	0.1	E	5	0.1	-	30	1	-	-
Vertical line objects	S	0.5	0.1	E	5	0.1	-	30	1	-	-
Construction area	S	1	0.1	-	5	0.1	-	5	0.1	-	-
Aerodrome reference point	C	30	1	R	30	1	R	30	1	R	-
Survey control point	S	0.5	0.01	E	0.5	0.01	E	NS	NS	-	-
Service road	S	1	0.1	-	5	0.1	-	30	1	-	-
Aerodrome boundary	C	NS	NS	-	NS	NS	-	NS	NS	-	-

Table 4-6. Vertical data quality requirements
(All values in meters; NS denotes not specified)

Data Element	Data Derivation	Fine			Medium			Coarse			Max Error
		A	R	I	A	R	I	A	R	I	
Runway threshold (non-precision)	S	0.5	0.1	E	NS	NS	-	NS	NS	-	3
Runway threshold (precision)	S	0.25	0.01	C	NS	NS	-	NS	NS	-	-
Painted centerline	S	1	0.1	-	NS	NS	-	NS	NS	-	6
Helipad threshold	S	0.5	0.1	C	NS	NS	-	NS	NS	-	-
Survey control point	S	0.25	0.01	E	NS	NS	-	NS	NS	-	-
Threshold elevation (non-precision)	S	0.5	0.1	E	NS	NS	-	NS	NS	-	3
Threshold elevation (precision)	S	0.25	0.01	C	NS	NS	-	NS	NS	-	-
Max height of vertical object	C	1	0.1	E	1	0.1	-	NS	NS	-	-
Max elevation of vertical object	S	1	0.1	E	1	0.1	-	NS	NS	-	-
Touchdown zone elevation	S	1	0.1	-	1	0.1	-	NS	NS	-	-

Table 4-7. Angular data quality requirements

Data Element	Data Derivation	Fine			Medium			Coarse			Max Error
		A	R	I	A	R	I	A	R	I	
True runway bearing	C	0.01°	0.01°	R	0.5°	0.01°	-	1.5°	0.1°	-	-
Magnetic runway bearing	S	0.01°	0.01°	R	0.5°	0.01°	-	1.5°	0.1°	-	-

Table 4-8. Dimensional data quality requirements
(All values in meters unless otherwise stated; NS denotes not specified)

Data Element	Data Derivation	Fine			Medium			Coarse			Max Error
		A	R	I	A	R	I	A	R	I	
Width of runway	C	0.5	0.01	R	1	0.1	-	5	0.1	-	-
Length of runway	C	1	0.1	C	5	0.1	-	30	1	-	-
Touchdown zone longitudinal slope	C	0.1%	0.01%	-	NS	NS	-	NS	NS	-	-
Runway slope	C	0.1%	0.01%	-	NS	NS	-	NS	NS	-	-
Take-off run available	C	1	0.1	E	5	0.1	-	30	1	-	-
Take-off distance available	C	1	0.1	E	5	0.1	-	30	1	-	-
Accelerating-stop-distance avail.	C	1	0.1	E	5	0.1	-	30	1	-	-
Landing distance available	C	1	0.1	C	5	0.1	-	30	1	-	-
Radius about center of obstacle	S	1	0.1	-	5	0.1	-	30	1	-	-
Max height of point structure	C	1	0.1	-	5	0.1	-	30	1	-	-

4.3 Aerodrome Mapping Data Product Specification (DPS)

4.3.1 Overview

AMDBs are typically constructed from photogrammetric images and/or manual surveys. The resulting database consists of vectors and attributes. Derived feature geometries are characterized as points, lines, or polygons. Examples include runway thresholds, hold lines, and aircraft stand locations. In AMDBs, the aerodrome surface is represented as well as certain natural and man-made features.

Aerodrome data represents geometric features that are classified. Examples of classifications include: runways, taxiways, service roads, localizer antennas, glide-slope antennas, buildings, and radio navigation aid. All features are described with their own set of attributes. Attributes describe the properties of a feature. Examples of attributes for a runway feature are runway name, threshold elevation, and magnetic bearing.

This chapter provides guidelines that must be followed to develop an aerodrome mapping DPS. These include: geometry and quality, feature extraction rules, the set of features, and the set of attributes for each feature. The features required are shown in Figure 4-22. Figure 4-23 details attributes associated with runway element features.

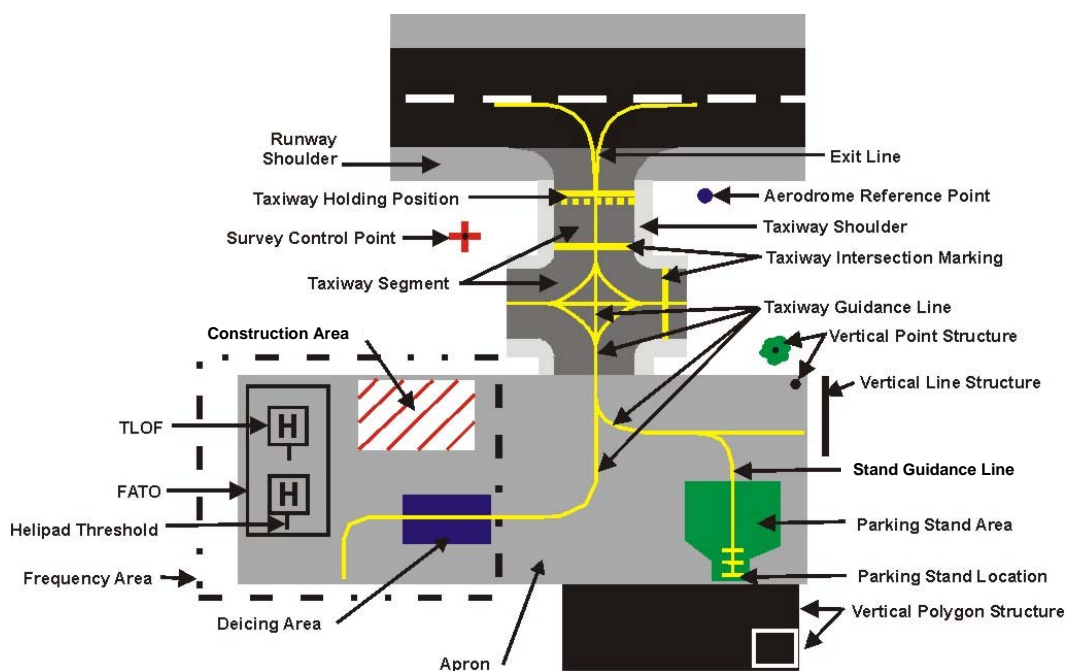


Figure 4-22. Aerodrome features

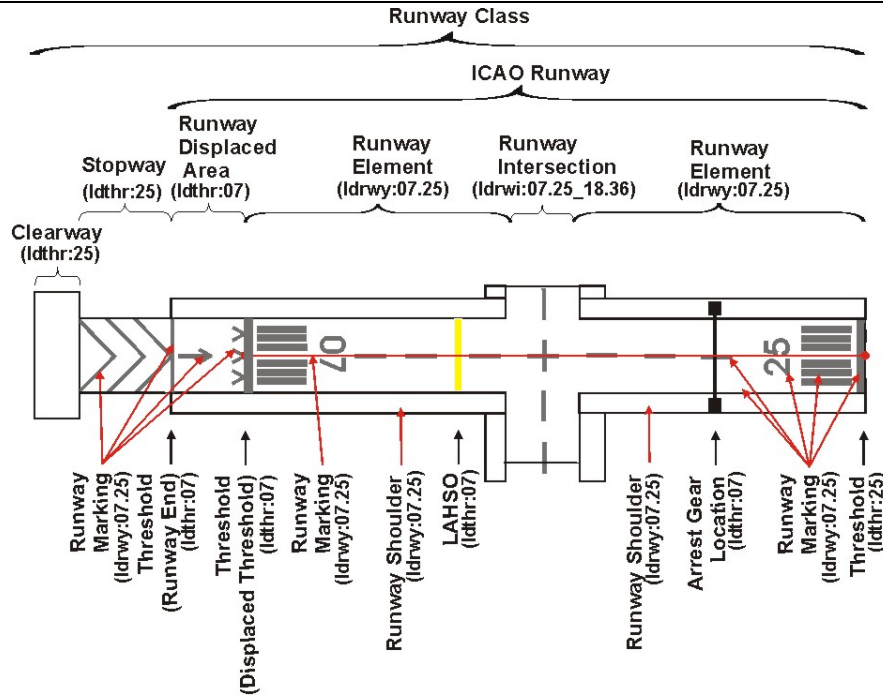


Figure 4-23. Runway feature

4.3.2 Specification Scopes

Aerodrome mapping data may not be homogeneous across the geographic area of the product, but may consist of subsets. For each such subset, the scope must be identified. For example, each subset may be defined by:

- » extent - the subset may have spatial, vertical or temporal extent constraints
- » feature type - the subset may be defined as a set of feature types

Example: This product contains all runway, taxiway, and apron features.

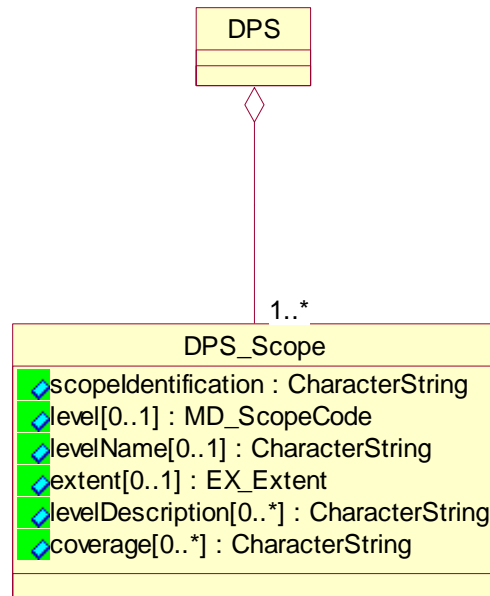
- » coverage - the subset may be a set of coverages within the data

Example: This product contains all aerodromes in Mexico.

Requirements for identifying the specification scope for aerodrome mapping data products are listed in Table 4-9, while the UML model is given in Figure 4-24.

Table 4-9. Identification of specification scopes for aerodrome mapping data

Item Name	Definition	Obligation/ Condition	Mult.	Data Type	Domain
Scope identification	Identification of the scope for the purpose of a particular data specification	M	1	Character String	Free text
level	hierarchical level of the data specified by the scope	O	1	Class	MD_Scope Code <<codeList>>
levelName	name of the hierarchy level of the data specified by the scope	O	1	Character String	Free text
Extent	information about the spatial, vertical and temporal extent of the data specified by the scope	O	1	Class	EX_Extent
levelDescription	detailed description about the level of the data specified by the scope	O	N	Character String	Free text
Coverage	coverages to which the information applies	O	N	Character String	Free text

**Figure 4-24. UML model for scope information for aerodrome mapping data**

4.3.3 Data Product Identification

Requirements for identifying aerodrome mapping data products are listed in Table 4-10, while the UML model is given in Figure 4-25. The mandatory items listed in Table 4-10 are described below.

- » title - the title of the data product

Example: The title of this product is the Denver International Airport (DIA) Mapping Database.

- » abstract - a brief narrative summary of the content of the data product

Example: This product contains all aerodrome mapping features specified for DIA.

- » topic category - the main theme(s) of the data product

Example: MD_TopicCategoryCode 018 – Transportation.

- » geographic description: description of geographic area covered by data product

Example: The DIA data set covers the airport surface movement area plus 50 meters.

Table 4-10. Identification information for aerodrome mapping data

Item Name	Definition	Obligation/ Condition	Multi.	Data Type	Domain
Title	title of data product	M	1	Character String	Free text
alternateTitle	other name by which the data product is known	O	N	Character String	Free text
Abstract	brief narrative summary of the content of the data product	M	1	Character String	Free text
Purpose	summary of the intentions with which the data product is developed	O	1	Character String	Free text
TopicCategory	main theme(s) of the data set	M	N	Class	MD_TopicCategoryCode <<CodeList>>
spatialRepresentationType	form of spatial representation	O	N	Class	MD_Spatial RepresentationTypeCode
spatialResolution	factor which provides a general understanding of the density of spatial data in the data set	O	N	Class	MD_Resolution <<Union>>
geographicDescription	description of the geographic area within which data is available	M	N	Class	EX_GeographicDescription
supplementalInformation	any other descriptive information about the data set	O	1	Character String	Free text

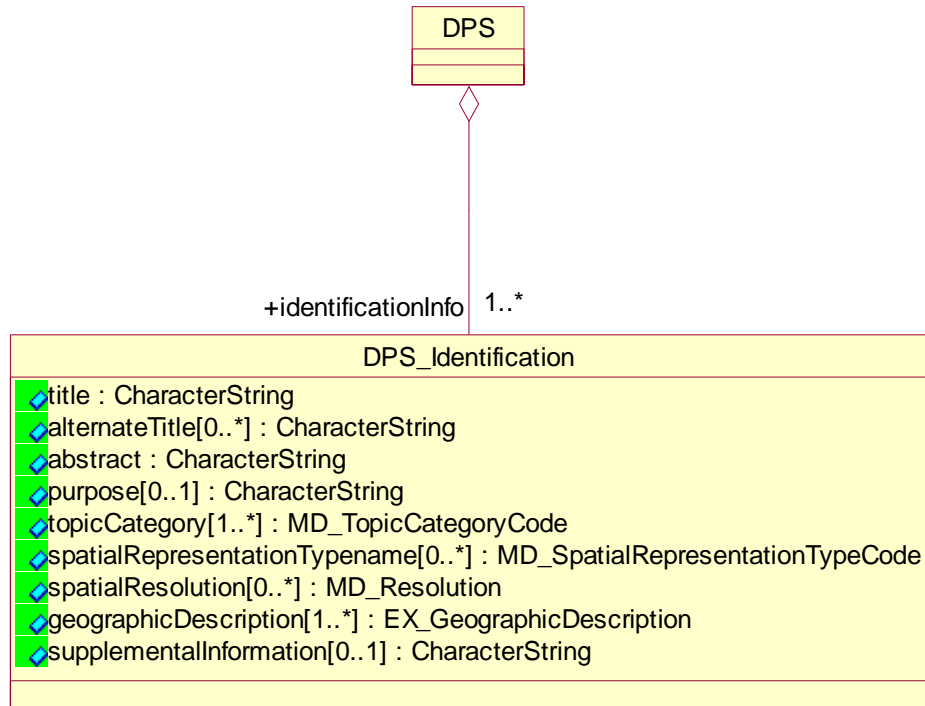


Figure 4-25. UML model for identification information for aerodrome mapping data

4.3.4 Data Content and Structure

The interchange of aerodrome mapping data products must comply with the application schema and feature catalogue stated below.

4.3.4.1 AMDB Application Schema

The AMDB application schema provides the common data model for aerodrome mapping data products. It complies with ISO 19109 (*Rules for Application Schema*) and uses Unified Modeling Language (UML) representations.

The application schema for aerodrome mapping data products reflects the requirements described in this document. This application schema is to be used by system implementers to develop conforming data interchange processes and formats. It is not the intention of the application schema to impose a given format, but rather to declare and standardize all common aerodrome mapping features and attributes, thereby enabling a standardized interchange of information.

Using the ISO 19100 series of standards for Geographic Information as the reference data-modeling framework implies an adherence to a common methodology with the intention to facilitate interoperability developments. ISO 19100 types have been used where appropriate. Moreover, in the case of metadata, the data structure has been derived from the ISO 19115 abstract metadata specification.

The application schema for aerodrome mapping data products has been expressed using UML class diagrams in accordance with the ISO 19100 series of standards. Only data types and attributes that are relevant to the interchange of aerodrome mapping data have been specified. These diagrams are shown in Figures 4-26 to 4-37.

The model integration diagram (Figure 4-26) shows the dependencies between the application schema and other standard packages.

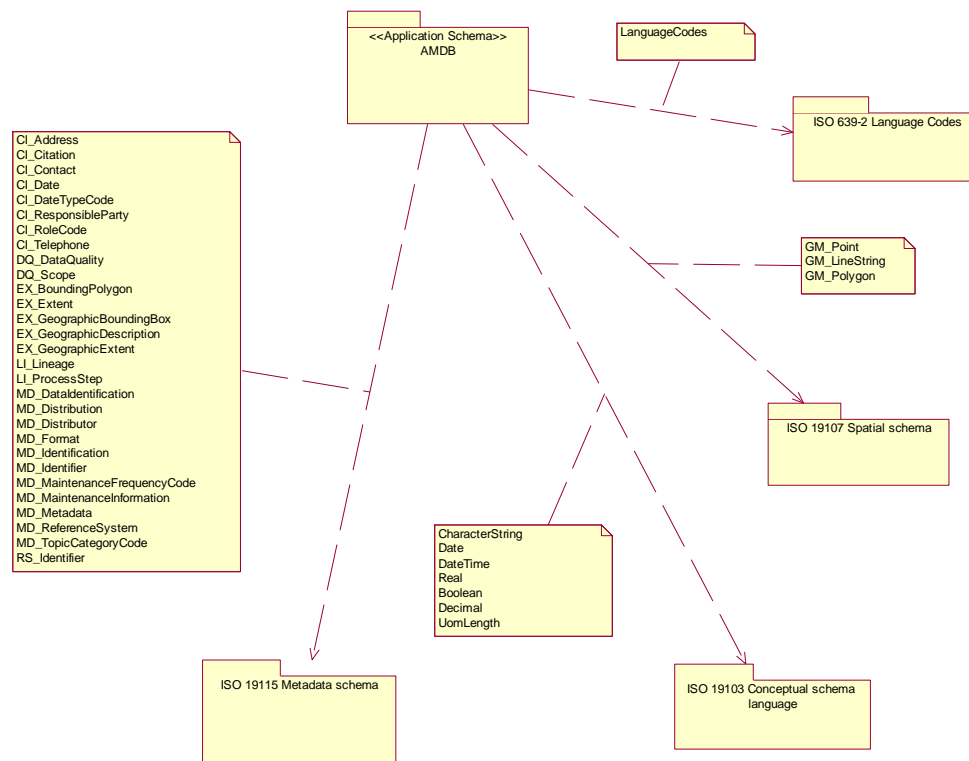


Figure 4-26. Model integration diagram for aerodrome mapping data

The application schema has been structured into two top-level packages, the feature types and the metadata types (Figure 4-27). Feature types reflect features and use attribute types and ISO 19100 types to define attributes and geometries. All aerodrome feature types, except AM_FrequencyArea and AM_ConstructionArea, use an abstract AM_FeatureBase type that holds common attributes. Features and attributes have been named according to the rules of ISO 19103 (*Conceptual Schema Language*).

Note (1): features and attributes have been named according to the rules of ISO 19103.

Note (2): the W3C string type is equivalent to the ISO 19103 CharacterString type.

Note (3): code lists/enumerations are used to define an open/closed range of possible values or equivalent codes. The general format for an enumeration is (Label: Type = Code).

Note (4): the default attribute multiplicity is 1; the multiplicity of an optional attribute is expressed as a range of values that begins with zero (e.g. [0..1]).

Note (5): the feature base class and its inheritance are used to reduce the complexity of the diagrams; flat relational representations as shown in the Feature Catalogue can be implemented as well.

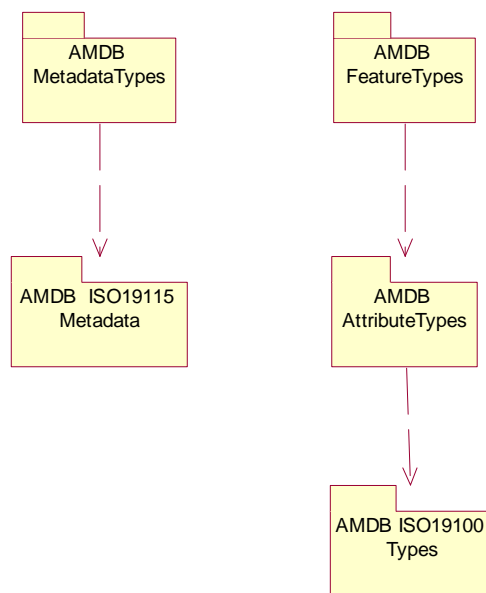


Figure 4-27. Application schema for aerodrome mapping data

Figure 4-28 defines the runway feature types for aerodrome mapping data products.

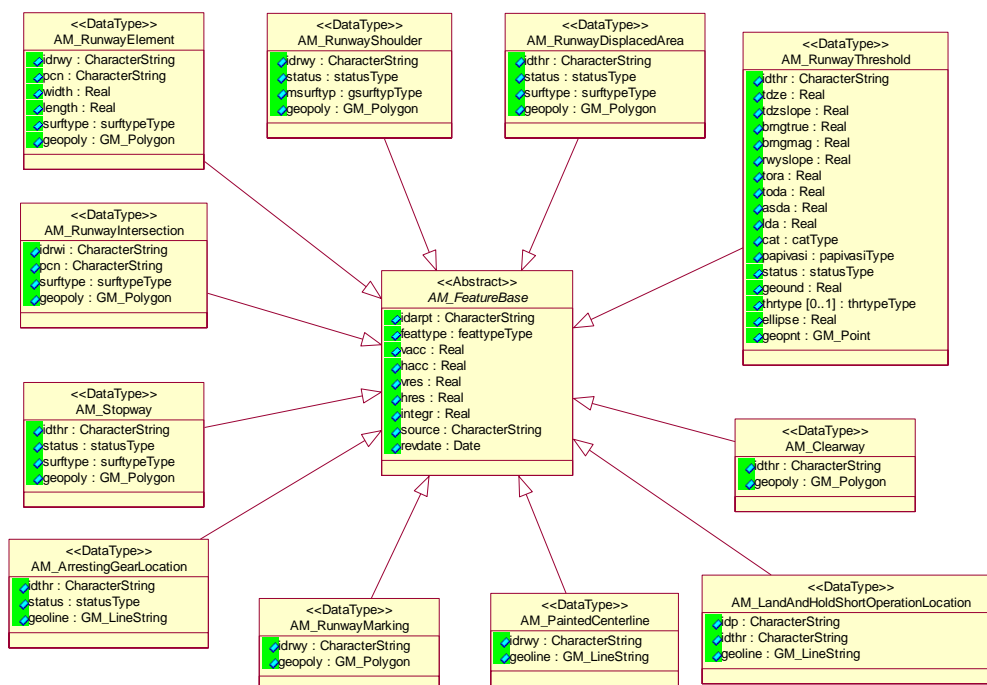


Figure 4-28. Runway feature types for aerodrome mapping data

Figure 4-29 defines the taxiway feature types for aerodrome mapping data products.

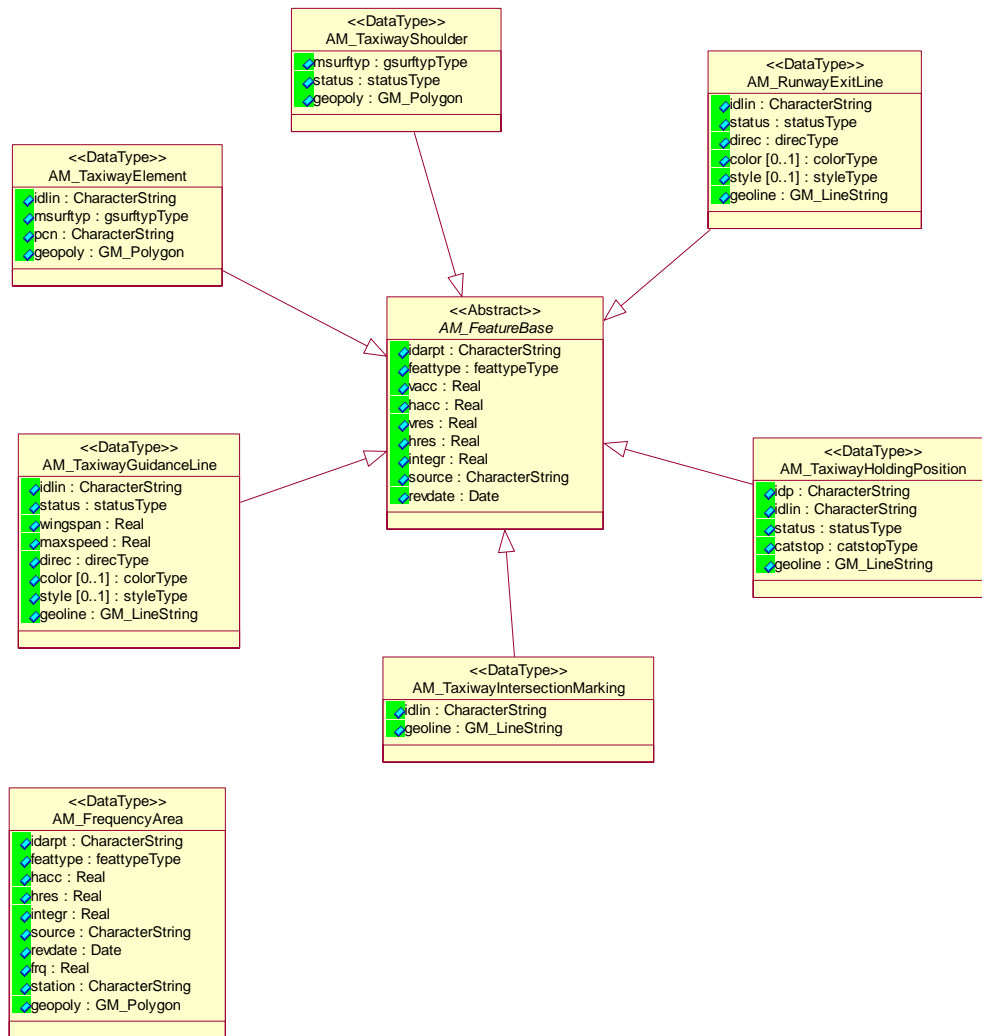


Figure 4-29. Taxiway feature types for aerodrome mapping data

Figure 4-30 defines the apron feature types for aerodrome mapping data products.

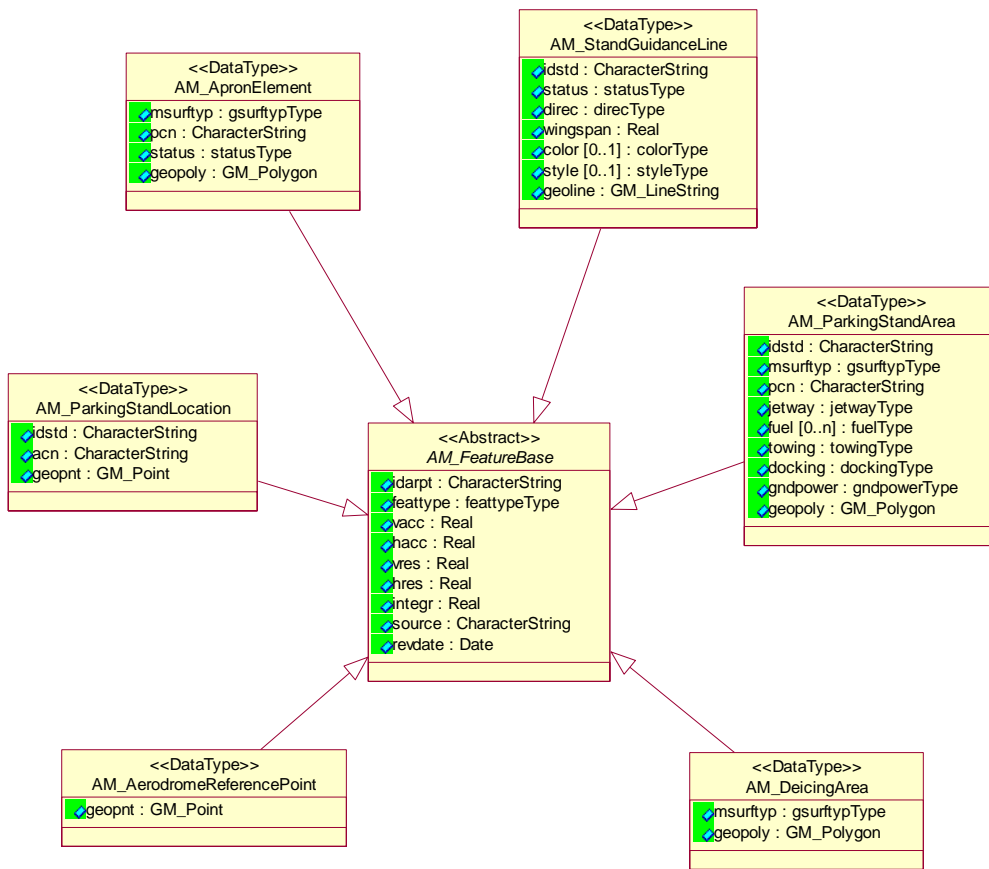


Figure 4-30. Apron feature types for aerodrome mapping data

Figure 4-31 defines the construction area feature types for aerodrome mapping data products.

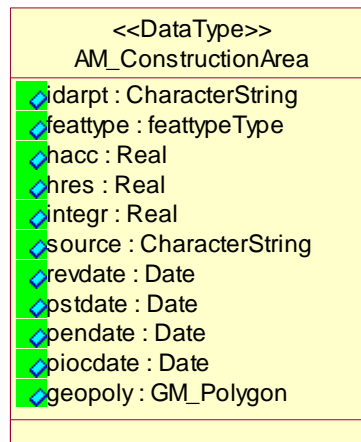


Figure 4-31. Construction area feature types for aerodrome mapping data

Figure 4-32 defines the helipad feature types for aerodrome mapping data products.

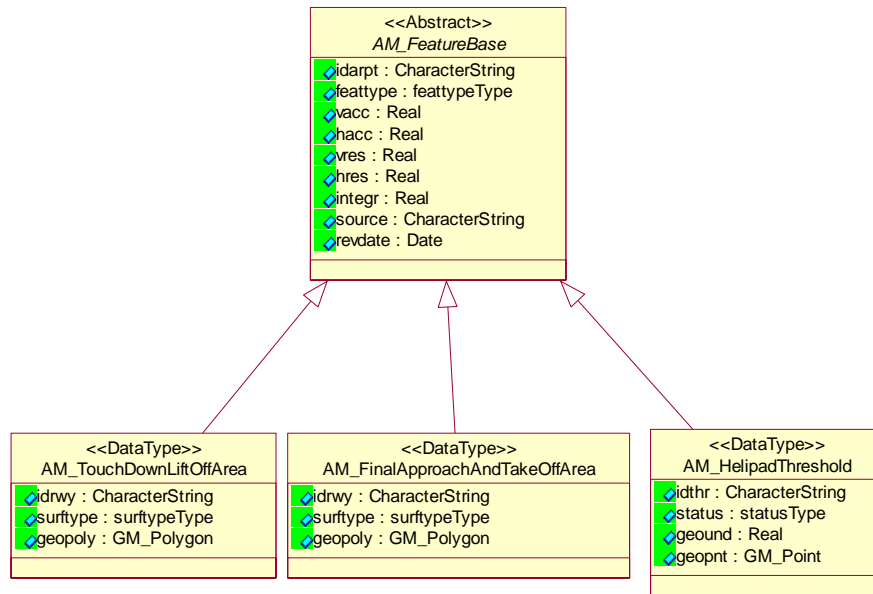


Figure 4-32. Helipad feature types for aerodrome mapping data

Figure 4-33 defines the vertical structure feature types for aerodrome mapping data products.

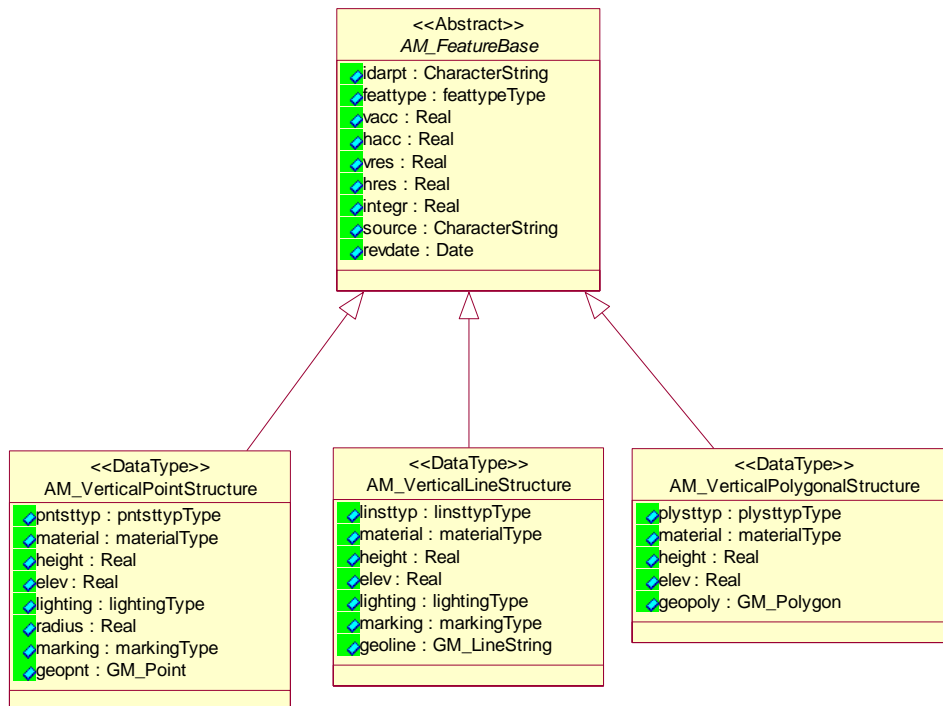


Figure 4-33. Vertical structure feature types for aerodrome mapping data

Figure 4-34 defines the surface lighting feature types for aerodrome mapping data products.

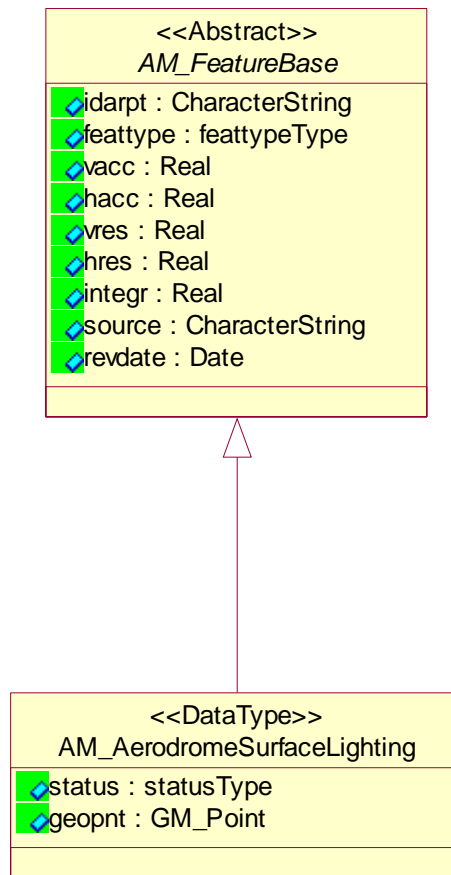


Figure 4-34. Surface lighting types for aerodrome mapping data

Figure 4-35 defines the survey control point feature types for aerodrome mapping data products.

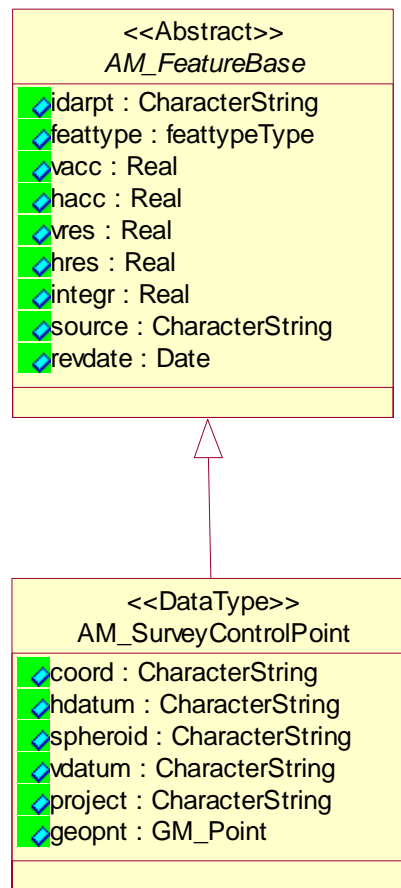


Figure 4-35. Survey control point types for aerodrome mapping data

Figure 4-36 defines the code list attribute types for aerodrome mapping data products. In Figure 4-36, the 'materialType' codes represent building materials used for vertical structures; 'gsurftype' codes represent surface materials used for apron areas; and 'surftype' codes represent surface materials used for runways.

<p><<CodeList>> fuelType</p> <ul style="list-style-type: none"> Jet A-1 = 1 Avgas 100 LL = 2 Mogas = 3 Jet B = 4 73 Oct = 5 80-87 = 6 100-130 = 7 115-145 = 8 Jet = 9 Jet A = 10 Jet A+ = 11 JP4 = 12 	<p><<codelist>> surftypeType</p> <ul style="list-style-type: none"> Concrete Grooved = 1 Concrete Non Grooved = 2 Asphalt Grooved = 3 Asphalt Non Grooved = 4 Desert or Sand or Dirt = 5 Bare Earth = 6 Snow or Ice = 7 Water = 8 Grass or Turf = 9 Aggregate Friction Seal Coat = 10 Gravel or Cinders = 11 Porous Friction Courses = 12 Pierced Steel Planks = 13 Rubberized Friction Seal Coat = 14
<p><<codelist>> plysttypType</p> <ul style="list-style-type: none"> Terminal Building = 1 Hangar = 2 Control Tower = 3 Non Terminal Building = 4 Tank = 5 Tree = 6 Bush = 7 Forest = 8 Earthen Works = 9 	<p><<codelist>> gsurftypType</p> <ul style="list-style-type: none"> Concrete = 1 Asphalt = 2 Desert or Sand or Dirt = 3 Bare Earth = 4 Snow or Ice = 5 Water = 6 Grass or Turf = 7 Gravel or Cinders = 8 Pierced Steel Planks = 9
<p><<codelist>> materialType</p> <ul style="list-style-type: none"> Concrete = 1 Metal = 2 Stone or Brick = 3 Composition = 4 Rock = 5 Earthen Works = 6 Wood = 7 	<p><<codelist>> pntsttypType</p> <ul style="list-style-type: none"> Smokestack = 1 Powerline Pylon = 2 Antenna = 3 Windsock = 4 Tree = 5 Lightpole = 6 Light Stanchion = 7
<p><<codelist>> insttypType</p> <ul style="list-style-type: none"> Power Line = 1 Cable Railway = 2 Bushes or Trees = 3 Wall = 4 	

Figure 4-36. Code list attribute types for aerodrome mapping data

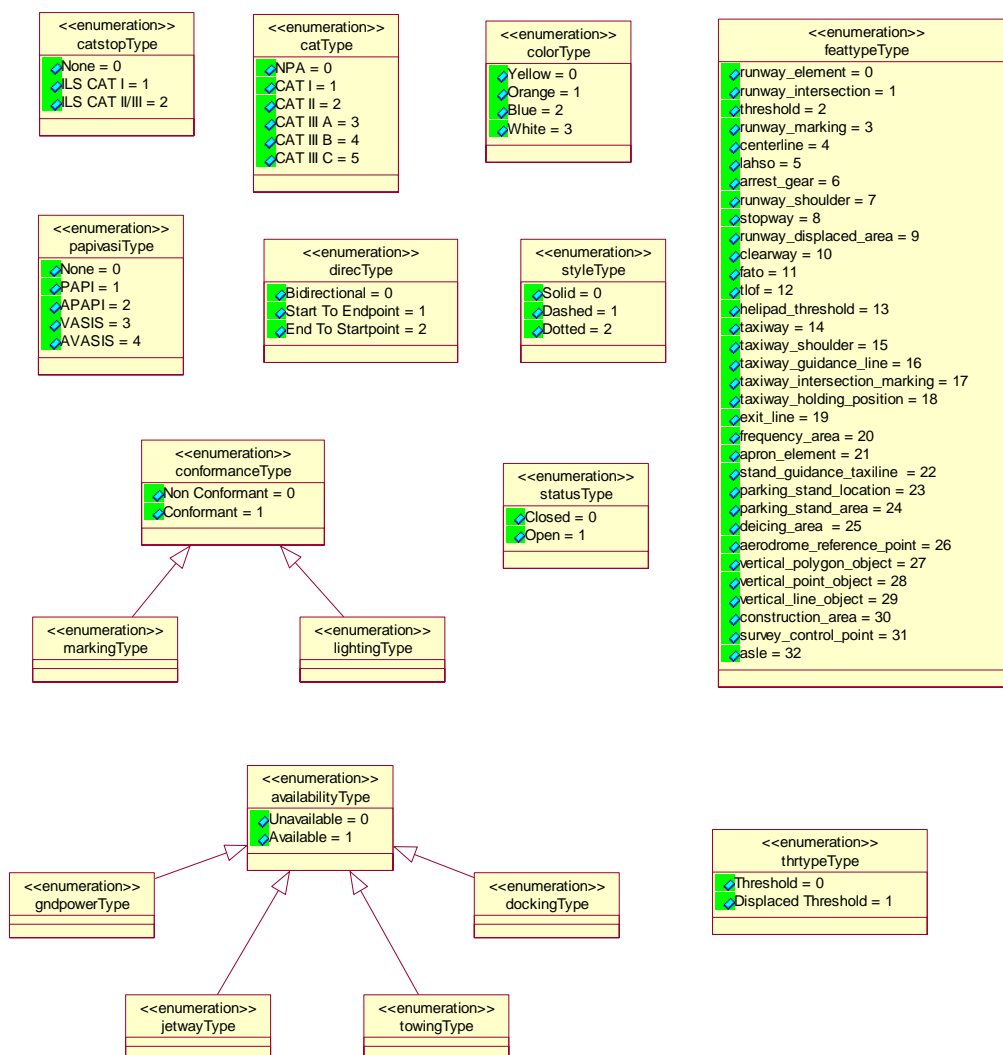


Figure 4-37. Enumeration attribute types for aerodrome mapping data

4.3.4.2 AMDB Feature Catalogue

This feature catalogue was developed in accordance with ISO 19110 and provides the minimum required set of attributes as defined in this document. Where feature attribute values are included, both the label and the code must be provided in the file that is to be interchanged.

Name: Aerodrome Mapping Feature Catalogue
Scope: Features as specified in this document
Version Number: 1.0
Version Date: <insert publication date (e.g. 16.02.2007/18:00)>
Definition Source: Annex 15 and Guidelines for Electronic Terrain, Obstacle and Aerodrome Mapping Information
Definition Type:

Feature Type: 'RunwayElement'

Name: RunwayElement
Aliases: AM_RunwayElement
Definition: Part of a runway.
Attribute Names: feattype, idarpt, idrwy, vacc, hacc, vres, hres, source, integr, revdate, pcn, width, length, surftype, geopoly,

Feature Type: 'RunwayIntersection'

Name: RunwayIntersection
Aliases: AM_RunwayIntersection
Definition: Intersecting area of two or more runways.
Attribute Names: feattype, idarpt, idrwi, vacc, hacc, vres, hres, source, integr, revdate, pcn, surftype, geopoly,

Feature Type: 'RunwayThreshold'

Name: RunwayThreshold
Aliases: AM_RunwayThreshold
Definition: The beginning of that portion of the runway that is available for landing.
Attribute Names: feattype, idarpt, idthr, vacc, hacc, vres, hres, source, integr, revdate, tdze, tdzslope, brngtrue, brngmag, rwyslope, tora, toda, asda, lda, cat, papivasi, status, geound, geopnt, thrtype, ellipse,

Feature Type: 'RunwayMarking'

Name: RunwayMarking

Aliases: AM_RunwayMarking

Definition: A symbol or group of symbols displayed on the surface of the runway in order to convey aeronautical information.

Attribute Names: featype, idarpt, idrwy, vacc, hacc, vres, hres, source, integr, revdate, geoply,

Feature Type: 'PaintedCenterline'

Name: PaintedCenterline

Aliases: AM_PaintedCenterline

Definition: Continuous painted line in the center of a runway connecting the two thresholds.

Attribute Names: featype, idarpt, idrwy, vacc, hacc, vres, hres, source, integr, revdate, geoline,

Feature Type: 'LandAndHoldShortOperationLocation'

Name: LandAndHoldShortOperationLocation

Aliases: AM_LandAndHoldShortOperationLocation

Definition: Location of marking used for Land and Hold Short Operations (LAHSO).

Attribute Names: featype, idarpt, idthr, vacc, hacc, vres, hres, source, integr, revdate, idp, geoline,

Feature Type: 'ArrestingGearLocation'

Name: ArrestingGearLocation

Aliases: AM_ArrestingGearLocation

Definition: Location of the arresting gear cable across the runway.

Attribute Names: featype, idarpt, idthr, vacc, hacc, vres, hres, source, integr, revdate, status, geoline,

Feature Type: 'RunwayShoulder'

Name: RunwayShoulder

Aliases: AM_RunwayShoulder

Definition: An area adjacent to the edge of a runway pavement so prepared as to provide a transition between the pavement and the adjacent surface.

Attribute Names: feattype, idarpt, idrwy, vacc, hacc, vres, hres, source, integr, revdate, status, gsurftyp, geopoly,

Feature Type: 'Stopway'

Name: Stopway

Aliases: AM_Stopway

Definition: A defined rectangular area on the ground at the end of take-off run available prepared as a suitable area in which an aircraft can be stopped in the case of an abandoned take-off.

Attribute Names: feattype, idarpt, idthr, vacc, hacc, vres, hres, source, integr, revdate, status, surftype, geopoly,

Feature Type: 'RunwayDisplacedArea'

Name: RunwayDisplacedArea

Aliases: AM_RunwayDisplacedArea

Definition: That portion of a runway between the beginning of the runway and the displaced threshold.

Attribute Names: feattype, idarpt, idthr, vacc, hacc, vres, hres, source, integr, revdate, status, surftype, geopoly,

Feature Type: 'Clearway'

Name: Clearway

Aliases: AM_Clearway

Definition: A defined rectangular area on the ground or water under the control of the appropriate authority, selected or prepared as a suitable area over which an aeroplane may make a portion of its initial climb to a specified height.

Attribute Names: feattype, idarpt, idthr, vacc, hacc, vres, hres, source, integr, revdate, geopoly,

Feature Type: 'FinalApproachAndTake-offArea'

Name: FinalApproachAndTake-offArea

Aliases: AM_FinalApproachAndTake-offArea

Definition: A defined area over which the final phase of the approach manoeuvre to hover or landing is completed or from which the take-off manoeuvre is commenced.

Attribute Names: featype, idarpt, idrwy, vacc, hacc, vres, hres, source, integr, revdate, surftype, geopoly,

Feature Type: 'TouchDownLiftOffArea'

Name: TouchDownLiftOffArea

Aliases: AM_TouchDownLiftOffArea

Definition: A load bearing area on which a helicopter may touchdown or lift-off.

Attribute Names: featype, idarpt, idrwy, vacc, hacc, vres, hres, source, integr, revdate, surftype, geopoly,

Feature Type: 'HelipadThreshold'

Name: HelipadThreshold

Aliases: AM_HelipadThreshold

Definition: The beginning of that portion of the helipad that is available for landing.

Attribute Names: featype, idarpt, idthr, vacc, hacc, vres, hres, source, integr, revdate, status, geound, geopnt,

Feature Type: 'TaxiwayElement'

Name: TaxiwayElement

Aliases: AM_TaxiwayElement

Definition: Part of a taxiway.

Attribute Names: featype, idarpt, idlin, vacc, hacc, vres, hres, source, integr, revdate, gsurftyp, pcn, geopoly,

Feature Type: 'TaxiwayShoulder'

Name: TaxiwayShoulder

Aliases: AM_TaxiwayShoulder

Definition: An area adjacent to the edge of a taxiway pavement so prepared as to provide a transition between the pavement and the adjacent surface.

Attribute Names: feattype, idarpt, vacc, hacc, vres, hres, source, integr, revdate, gsurftyp, status, geopoly,

Feature Type: 'TaxiwayGuidanceLine'

Name: TaxiwayGuidanceLine

Aliases: AM_TaxiwayGuidanceLine

Definition: Guidance center line painted on a taxiway.

Attribute Names: feattype, idarpt, idlin, vacc, hacc, vres, hres, source, integr, revdate, status, wingspan, maxspeed, color, style, direc, geoline,

Feature Type: 'TaxiwayIntersectionMarking'

Name: TaxiwayIntersectionMarking

Aliases: AM_TaxiwayIntersectionMarking

Definition: Taxiway intersection marking painted across a taxiway.

Attribute Names: feattype, idarpt, idlin, vacc, hacc, vres, hres, source, integr, revdate, geoline,

Feature Type: 'TaxiwayHoldingPosition'

Name: TaxiwayHoldingPosition

Aliases: AM_TaxiwayHoldingPosition

Definition: Taxiway holding position painted across a taxiway.

Attribute Names: feattype, idarpt, idlin, vacc, hacc, vres, hres, source, integr, revdate, status, catstop, idp, geoline,

Feature Type: 'RunwayExitLine'

Name: RunwayExitLine

Aliases: AM_RunwayExitline

Definition: Guidance line painted on the runway exit.

Attribute Names: feattype, idarpt, idlin, vacc, hacc, vres, hres, source, integr, revdate, status, color, style, direc, geoline,

Feature Type: 'FrequencyArea'

Name: FrequencyArea

Aliases: AM_FrequencyArea

Definition: Designated part of a surface movement area where a specific frequency is required by air traffic control or ground control.

Attribute Names: feattype, idarpt, hacc, hres, source, integr, revdate, frq, station, geopoly,

Feature Type: 'ApronElement'

Name: ApronElement

Aliases: AM_ApronElement

Definition: Part of a defined area, on a land aerodrome, intended to accommodate aircraft for purposes of loading or unloading passengers, mail or cargo, fuelling, parking, or maintenance.

Attribute Names: feattype, idarpt, vacc, hacc, vres, hres, source, integr, revdate, gsurftyp, pcn, status, geopoly,

Feature Type: 'StandGuidanceLine'

Name: StandGuidanceLine

Aliases: AM_StandGuidanceLine

Definition: Guidance line on a designated area on an apron intended to be used for parking an aircraft.

Attribute Names: feattype, idarpt, idstd, vacc, hacc, vres, hres, source, integr, revdate, status, color, style, direc, wingspan, geoline,

Feature Type: 'ParkingStandLocation'

Name: ParkingStandLocation

Aliases: AM_ParkingStandLocation

Definition: Location of an aircraft stand.

Attribute Names: featype, idarpt, idstd, vacc, hacc, vres, hres, source, integr, revdate, acn, geopnt,

Feature Type: 'ParkingStandArea'

Name: ParkingStandArea

Aliases: AM_ParkingStandArea

Definition: A designated area on an apron intended to be used for parking an aircraft.

Attribute Names: featype, idarpt, idstd, vacc, hacc, vres, hres, source, integr, revdate, gsurftyp, pcn, jetway, fuel, towing, docking, gndpower, geopoly,

Feature Type: 'DeicingArea'

Name: DeicingArea

Aliases: AM_DeicingArea

Definition: An area comprising an inner area for the parking of an aeroplane to receive de-icing treatment and an outer area for the manoeuvring of two or more mobile de-icing equipment.

Attribute Names: featype, idarpt, vacc, hacc, vres, hres, source, integr, revdate, gsurftyp, geopoly,

Feature Type: 'AerodromeReferencePoint'

Name: AerodromeReferencePoint

Aliases: AM_AerodromeReferencePoint

Definition: The designated geographical location of an aerodrome.

Attribute Names: featype, idarpt, vacc, hacc, vres, hres, source, integr, revdate, geopnt,

Feature Type: 'VerticalPolygonStructure'

Name: VerticalPolygonStructure

Aliases: AM_VerticalPolygonStructure

Definition: Polygonal structure of a defined vertical extent that is located within a movement zone.

Attribute Names: featype, idarpt, plysttyp, vacc, hacc, vres, hres, source, integr, revdate, material, height, elev, geopoly,

Feature Type: 'VerticalPointStructure'

Name: VerticalPointStructure

Aliases: AM_VerticalPointStructure

Definition: Point structure of a defined vertical extent that is located within a movement zone.

Attribute Names: featype, idarpt, pntsttyp, vacc, hacc, vres, hres, source, integr, revdate, material, height, elev, lighting, radius, marking, geopnt,

Feature Type: 'VerticalLineStructure'

Name: VerticalLineStructure

Aliases: AM_VerticalLineStructure

Definition: Line structure of a defined vertical extent that is located within a movement zone.

Attribute Names: featype, idarpt, linsttyp, vacc, hacc, vres, hres, source, integr, revdate, material, height, elev, lighting, marking, geoline,

Feature Type: 'ConstructionArea'

Name: ConstructionArea

Aliases: AM_ConstructionArea

Definition: Part of aerodrome movement area under construction.

Attribute Names: featype, idarpt, hacc, hres, source, integr, revdate, pstdate, pendate, piocdate, geopoly,

Feature Type: 'SurveyControlPoint'

Name: SurveyControlPoint

Aliases: AM_SurveyControlPoint

Definition: A monumented survey control point.

Attribute Names: feattype, idarpt, vacc, hacc, vres, hres, source, integr, revdate, coord, hdatum, spheroid, vdatum, project, geopnt,

Feature Type: 'AerodromeSurfaceLighting'

Name: AerodromeSurfaceLighting

Aliases: AM_AerodromeSurfaceLighting

Definition: Lighting within a movement area.

Attribute Names: feattype, idarpt, vacc, hacc, vres, hres, source, integr, revdate, status, geopnt,

Feature Attribute: 'feattype'

Name: feattype

Definition: Feature type.

Value Data Type: CharacterString

Value Measurement Unit:

Value Domain Type: 1

Value Domain: maximum 32 characters

Feature Attribute Values:	Label	Code	Definition
	runway_element	0	AM_RunwayElement
	runway_intersection	1	AM_RunwayIntersection
	threshold	2	AM_RunwayThreshold
	runway_marking	3	AM_RunwayMarking
	centerline	4	AM_PaintedCenterline
	lahso	5	AM_LandAndHoldShortOperation
	arrest_gear	6	AM_ArrestingGearLocation
	runway_shoulder	7	AM_RunwayShoulder
	stopway	8	AM_Stopway

runway_displaced_area	9	AM_RunwayDisplacedArea
clearway	10	AM_Clearway
fato	11	AM_FinalApproachAndTake-offArea
tlof	12	AM_TouchdownLiftoffArea
helipad_threshold	13	AM_HelipadThreshold
taxiway	14	AM_TaxiwayElement
taxiway_shoulder	15	AM_TaxiwayShoulder
taxiway_guidance_line	16	AM_TaxiwayGuidanceLine
taxiway_intersection_marking	17	AM_TaxiwayIntersectionMarking
taxiway_holding_position	18	AM_TaxiwayHoldingPosition
exit_line	19	AM_RunwayExitline
frequency_area	20	AM_FrequencyArea
apron_element	21	AM_ApronElement
stand_guidance_taxiline	22	AM_StandGuidanceLine
parking_stand_location	23	AM_ParkingStandLocation
parking_stand_area	24	AM_ParkingStandArea
deicing_area	25	AM_DeicingArea
aerodrome_reference_point	26	AM_AerodromeReferencePoint
vertical_polygon_object	27	AM_VerticalPolygonalStructure
vertical_point_object	28	AM_VerticalPointStructure
vertical_line_object	29	AM_VerticalLineStructure
construction_area	30	AM_ConstructionArea
survey_control_point	31	AM_SurveyControlPoint
asle	32	AM_AerodromeSurfaceLighting

Feature Attribute: 'idarpt'

Name:	idarpt
Definition:	Location indicator: four-letter ICAO location indicator for geographical locations.
Value Data Type:	CharacterString
Value Measurement Unit:	
Value Domain Type:	0
Value Domain:	maximum 5 characters
Feature Attribute Values:	

Feature Attribute: 'idrwy'

Name:	idrwy
Definition:	Object identifier. Encoding: Runway/helipad-designator of both runway/helipad directions, separated by a ".". (beginning with smaller number). Example: 07L.25R
Value Data Type:	CharacterString
Value Measurement Unit:	
Value Domain Type:	0
Value Domain:	maximum 15 characters
Feature Attribute Values:	

Feature Attribute: 'vacc'

Name:	vacc
Definition:	Vertical accuracy of entity as a 95% linear error (LE).
Value Data Type:	Real
Value Measurement Unit:	meters
Value Domain Type:	0
Value Domain:	[0.00, 999.99]
Feature Attribute Values:	

Feature Attribute: 'hacc'

Name:	hacc
Definition:	Horizontal accuracy of entity as a 95%. circular error (CE).
Value Data Type:	Real
Value Measurement Unit:	meters
Value Domain Type:	0
Value Domain:	[0.00, 9999.99]
Feature Attribute Values:	

Feature Attribute: 'vres'

Name:	vres
Definition:	Vertical resolution of coordinates (height) defining the feature.
Value Data Type:	Real
Value Measurement Unit:	meters
Value Domain Type:	0
Value Domain:	[0.0001, 999.9999]
Feature Attribute Values:	

Feature Attribute: 'hres'

Name:	hres
Definition:	Horizontal resolution of coordinates (latitude, longitude) defining the feature.
Value Data Type:	Real
Value Measurement Unit:	Decimal Degrees
Value Domain Type:	0
Value Domain:	[0.00000001, 0.001]
Feature Attribute Values:	

Feature Attribute: 'source'

Name: source

Definition: Name of entity or organization that supplied data. In case of initial data origination, name of data originator.

Value Data Type: CharacterString

Value Measurement Unit:

Value Domain Type: 0

Value Domain: maximum 64 characters

Feature Attribute Values:

Feature Attribute: 'integr'

Name: integr

Definition: Integrity of data in the aeronautical data processing chain from data origination to any data manipulation process.

Value Data Type: Real

Value Measurement Unit:

Value Domain Type: 0

Value Domain: [0, 1]

Feature Attribute Values:

Feature Attribute: 'revdate'

Name: revdate

Definition: Date of origination or of last data revision

Value Data Type: Date

Value Measurement Unit:

Value Domain Type: 0

Value Domain:

Feature Attribute Values:

Feature Attribute: 'pcn'

Name:	pcn
Definition:	Weight bearing capability of surface. Encoding: Aircraft classification number - pavement classification number (ACN-PCN).The format is specified in Annex 14, Volume I, paragraph 2.6. Example: PCN80/R/B/W/T
Value Data Type:	CharacterString
Value Measurement Unit:	
Value Domain Type:	0
Value Domain:	maximum 32 characters
Feature Attribute Values:	

Feature Attribute: 'width'

Name:	width
Definition:	minimum width of feature.
Value Data Type:	Real
Value Measurement Unit:	meters
Value Domain Type:	0
Value Domain:	[0.00, 99.99]
Feature Attribute Values:	

Feature Attribute: 'length'

Name:	length
Definition:	length of feature.
Value Data Type:	Real
Value Measurement Unit:	meters
Value Domain Type:	0
Value Domain:	[0.00, 99999.99]
Feature Attribute Values:	

Feature Attribute: 'surftype'

Name: surftype

Definition: Predominant surface type. Example: for concrete grooved: 1

Value Data Type: CharacterString

Value Measurement Unit:

Value Domain Type: 1

Value Domain:

Feature Attribute Values:	Label	Code	Definition
	Concrete Grooved	1	Concrete Grooved
	Concrete Non Grooved	2	Concrete Non Grooved
	Asphalt Grooved	3	Asphalt Grooved
	Asphalt Non Grooved	4	Asphalt Non Grooved
	Desert or Sand or Dirt	5	Desert or Sand or Dirt
	Bare Earth	6	Bare Earth
	Snow or Ice	7	Snow or Ice
	Water	8	Water
	Grass or Turf	9	Grass or Turf
	Aggregate Friction Seal Coat	10	Aggregate Friction Seal Coat
	Gravel or Cinders	11	Gravel or Cinders
	Porous Friction Courses	12	Porous Friction Courses
	Pierced Steel Planks	13	Pierced Steel Planks
	Rubberized Friction Seal Coat	14	Rubberized Friction Seal Coat

Feature Attribute: 'idrwi'

Name:	idrwi
Definition:	Object identifier. Encoding: object-designator of intersecting runways or stopway, separated by a "_". Example: Runway 07.25 and 18.36: 07.25_18.36
Value Data Type:	CharacterString
Value Measurement Unit:	
Value Domain Type:	0
Value Domain:	maximum 32 characters
Feature Attribute Values:	

Feature Attribute: 'idthr'

Name:	idthr
Definition:	object identifier. Encoding: Runway/helipad-designator of corresponding runway/helipad direction. Example: 07L
Value Data Type:	CharacterString
Value Measurement Unit:	
Value Domain Type:	0
Value Domain:	maximum 15 characters
Feature Attribute Values:	

Feature Attribute: 'tdze'

Name:	tdze
Definition:	Touchdown zone (Annex 14, Volume I,) elevation (Orthometric height) corresponding to threshold location.
Value Data Type:	Real
Value Measurement Unit:	meters
Value Domain Type:	0
Value Domain:	[-499.99, 8999.99]
Feature Attribute Values:	

Feature Attribute: 'tdzslope'

Name:	tdzslope
Definition:	Touchdown zone longitudinal slope (slope of 1/3 of the runway length from threshold or first 1000 meters (3000 feet) for runways longer than 3000 meters (9000 feet), corresponding to threshold location.
Value Data Type:	Real
Value Measurement Unit:	percent
Value Domain Type:	0
Value Domain:	[-9.99, 9.99]
Feature Attribute Values:	

Feature Attribute: 'brngtrue'

Name:	brngtrue
Definition:	True bearing corresponding to landing direction (Annex 14, Volume I, paragraph 3.1.12).
Value Data Type:	Real
Value Measurement Unit:	degree
Value Domain Type:	0
Value Domain:	[0.00, 359.99]
Feature Attribute Values:	

Feature Attribute: 'brngmag'

Name:	brngmag
Definition:	Magnetic runway bearing corresponding to threshold location valid at the day of data generation.
Value Data Type:	Real
Value Measurement Unit:	degree
Value Domain Type:	0
Value Domain:	[0.00, 359.99]
Feature Attribute Values:	

Feature Attribute: 'rwyslope'

Name: rwyslope

Definition: Runway slope corresponding to landing direction.

Value Data Type: Real

Value Measurement Unit: percent

Value Domain Type: 0

Value Domain: [-9.99, 9.99]

Feature Attribute Values:

Feature Attribute: 'tora'

Name: tora

Definition: Take-off run available (Annex 14, Volume I) corresponding to threshold location.

Value Data Type: Real

Value Measurement Unit: meters

Value Domain Type: 0

Value Domain: [0.00, 9999.99]

Feature Attribute Values:

Feature Attribute: 'toda'

Name: toda

Definition: Take-off distance available (Annex 14, Volume I) corresponding to threshold location.

Value Data Type: Real

Value Measurement Unit: meters

Value Domain Type: 0

Value Domain: [0.00, 9999.99]

Feature Attribute Values:

Feature Attribute: 'asda'

Name:	asda
Definition:	Accelerate-stop distance available. (Annex 14, Volume I) corresponding to threshold location.
Value Data Type:	Real
Value Measurement Unit:	meters
Value Domain Type:	0
Value Domain:	[0.00, 9999.99]
Feature Attribute Values:	

Feature Attribute: 'lda'

Name:	lda
Definition:	Landing distance available (Annex 14, Volume I) corresponding to threshold location.
Value Data Type:	Real
Value Measurement Unit:	meters
Value Domain Type:	0
Value Domain:	[0.00, 9999.99]
Feature Attribute Values:	

Feature Attribute: 'cat'

Name: cat

Definition: Precision approach guidance system available corresponding to threshold location.

Value Data Type: CharacterString

Value Measurement Unit:

Value Domain Type: 1

Value Domain:

Feature Attribute Values:	Label	Code	Definition
	NPA	0	Non Precision Approach Runway
	CAT I	1	Precision Approach Runway, Category I
	CAT II	2	Precision Approach Runway, Category II
	CAT III A	3	Precision Approach Runway Category III A
	CAT III B	4	Precision Approach Runway Category III B
	CAT III C	5	Precision Approach Runway Category III C

Feature Attribute: 'papivasi'

Name: papivasi

Definition: Vertical guidance lighting system available corresponding to threshold location.

Value Data Type: CharacterString

Value Measurement Unit:

Value Domain Type: 1

Value Domain:

Feature Attribute Values:	Label	Code	Definition
	None	0	No visual slope indicator system
	PAPI	1	Precision Approach Path Indicator
	APAPI	2	Abbreviated Precision Approach Path Indicator
	VASIS	3	Visual Approach Slope Indicator System
	A-VASIS	4	Abbreviated Visual Approach Slope Indicator System

Feature Attribute: 'status'

Name: status

Definition: Permanent state of feature. *Note. Non-permanent closures or outages are not addressed in the AMDB.*

Value Data Type: CharacterString

Value Measurement Unit:

Value Domain Type: 1

Value Domain:

Feature Attribute Values:	Label	Code	Definition
	Closed	0	Closed or Unusable or Non-Operational
	Open	1	Open or Usable or Operational

Feature Attribute: 'ellipse'

Name: ellipse

Definition: Height above/below the WGS-84 ellipsoid at threshold position.

Value Data Type: Real

Value Measurement Unit: Meters

Value Domain Type: 0

Value Domain: [-999.99,9999.99]

Feature Attribute Values:

Feature Attribute: 'geound'

Name: Geound

Definition: Geoid undulation at threshold position.

Value Data Type: Real

Value Measurement Unit: meters

Value Domain Type: 0

Value Domain: [-99.99, 99.99]

Feature Attribute Values:

Feature Attribute: 'thrtype'

Name: thrtype

Definition: Type of threshold.

Value Data Type: CharacterString

Value Measurement Unit:

Value Domain Type: 1

Value Domain:

Feature Attribute Values:	Label	Code	Definition
	Threshold	0	Threshold
	Displaced Threshold	1	Displaced Threshold

Feature Attribute: 'idp'

Name: idp

Definition: Object identifier of runway or taxiway being protected.
Encoding: Corresponding runway-designator of both runway direction, separated by a ".". (beginning with smaller number). Example: 07L.25R

Value Data Type: CharacterString

Value Measurement Unit:

Value Domain Type: 0

Value Domain: maximum 15 characters

Feature Attribute Values:

Feature Attribute: 'gsurftyp'

Name: gsurftyp

Definition: Generic surface type. Example: Concrete: 1

Value Data Type: CharacterString

Value Measurement Unit:

Value Domain Type: 1

Value Domain:

Feature Attribute Values:

Label	Code	Definition
Concrete	1	Concrete
Asphalt	2	Asphalt
Desert or Sand or Dirt	3	Desert or Sand or Dirt
Bare Earth	4	Bare Earth
Snow or Ice	5	Snow or Ice
Water	6	Water
Grass or Turf	7	Grass or Turf
Gravel or Cinders	8	Gravel or Cinders
Pierced Steel Planks	9	Pierced Steel Planks

Feature Attribute: 'idlin'

Name:	idlin
Definition:	Object identifier. Encoding: Taxiway segment name. The name should be identical to the corresponding taxiway name. Multiple taxiway segments can have the same name. If two or more taxiways intersect the taxiway segment intersection will be named after the predominant taxiway. If two taxiways on the same level intersect the segment may be named arbitrary after one of the taxiways. If a specific name for the intersection exists the corresponding segment must be named thereafter.
Value Data Type:	CharacterString
Value Measurement Unit:	
Value Domain Type:	0
Value Domain:	maximum 15 characters
Feature Attribute Values:	

Feature Attribute: 'wingspan'

Name:	wingspan
Definition:	Maximum wingspan on taxiway.
Value Data Type:	Real
Value Measurement Unit:	meters
Value Domain Type:	0
Value Domain:	[0, 80]
Feature Attribute Values:	

Feature Attribute: 'maxspeed'

Name: maxspeed

Definition: Maximum speed on taxiway.

Value Data Type: Real

Value Measurement Unit: knots

Value Domain Type: 0

Value Domain: [0, 50]

Feature Attribute Values:

Feature Attribute: 'color'

Name: color

Definition: Color specifying the color of the taxi-line.

Value Data Type: CharacterString

Value Measurement Unit:

Value Domain Type: 1

Value Domain:

Feature Attribute Values:	Label	Code	Definition
	Yellow	0	Yellow
	Orange	1	Orange
	Blue	2	Blue
	White	3	White

Feature Attribute: 'style'

Name: style

Definition: Style specifying the line property of the taxi-line.

Value Data Type: CharacterString

Value Measurement Unit:

Value Domain Type: 1

Value Domain:

Feature Attribute Values:	Label	Code	Definition
	Solid	0	Solid
	Dashed	1	Dashed
	Dotted	2	Dotted

Feature Attribute: 'direc'

Name: direc

Definition: Directionality of a corresponding taxiway. Taxiway can be one- or two-way.

Value Data Type: CharacterString

Value Measurement Unit:

Value Domain Type: 1

Value Domain:

Feature Attribute Values:	Label	Code	Definition
	Bidirectional	0	Bidirectional
	Start To Endpoint	1	One way from start-to-endpoint
	End To Start point	2	One way from end-to-start point

Feature Attribute: 'catstop'

Name: catstop

Definition: Low visibility operation category of stopbar. Encoding: Code describing the Low visibility operation category of stopbar.

Value Data Type: CharacterString

Value Measurement Unit:

Value Domain Type: 1

Value Domain:

Feature Attribute Values:	Label	Code	Definition
	None	0	No low visibility operation supported
	CAT I	1	Supports ILS CAT I low visibility operation
	CAT II/III	2	Supports ILS CATII/III low visibility operations

Feature Attribute: 'frq'

Name: frq

Definition: Primary frequency used on frequency area.

Value Data Type: Real

Value Measurement Unit: MHZ

Value Domain Type: 0

Value Domain: [117.975, 136.000]

Feature Attribute Values:

Feature Attribute: 'station'

Name:	station
Definition:	Service or station assigned to primary frequency (e.g. ATC Tower, Ground Control).
Value Data Type:	CharacterString
Value Measurement Unit:	
Value Domain Type:	0
Value Domain:	maximum 32 characters
Feature Attribute Values:	

Feature Attribute: 'idstd'

Name:	idstd
Definition:	Object identifier. Encoding: official parking stand identification. Stand Guidance Taxi-lines should be assigned with the adjacent parking stand area feature object identifier(idstd). Example: A22 for a stand area with a single line, A21_A22 for a stand area with two lines
Value Data Type:	CharacterString
Value Measurement Unit:	
Value Domain Type:	0
Value Domain:	maximum 32 characters
Feature Attribute Values:	

Feature Attribute: 'acn'

Name: acn

Definition: Parking stand location's feasibility for specific aircraft type according ACN. Encoding: Aircraft type according to ACN for aircraft types painted on the apron. If there is more than one aircraft-type feasible for one parking stand location, the different types should be divided by a “.”. Example: 747-400 and A 340 at one location: B744.A340

Value Data Type: CharacterString

Value Measurement Unit:

Value Domain Type: 0

Value Domain: maximum 32 characters

Feature Attribute Values:

Feature Attribute: 'jetway'

Name: jetway

Definition: Availability of jetway.

Value Data Type: CharacterString

Value Measurement Unit:

Value Domain Type: 1

Value Domain:

Feature Attribute Values:

Label	Code	Definition
Unavailable	0	Unavailable
Available	1	Available

Feature Attribute: 'fuel'

Name: fuel

Definition: Types of fuel available. If multiple fuel types are available at a stand point all of them must be listed separated by a comma. Example: Jet A-1 and Mogas: 1,3

Value Data Type: CharacterString

Value Measurement Unit:

Value Domain Type: 1

Value Domain:

Feature Attribute Values:	Label	Code	Definition
	Jet A-1	1	Jet A-1
	Avgas 100 LL	2	Avgas 100 LL
	Mogas	3	Mogas
	Jet B	4	Jet B
	73 Oct	5	73 Oct
	80-87	6	80-87
	100-130	7	100-130
	115-145	8	115-145
	Jet	9	Jet
	Jet A	10	Jet A
	Jet A+	11	Jet A+
	JP4	12	JP4

Feature Attribute: 'towing'

Name:	towing		
Definition:	Availability of towing service.		
Value Data Type:	CharacterString		
Value Measurement Unit:			
Value Domain Type:	1		
Value Domain:			
Feature Attribute Values:	Label	Code	Definition
	Unavailable	0	Unavailable
	Available	1	Available

Feature Attribute: 'docking'

Name:	docking		
Definition:	Availability of docking guidance system.		
Value Data Type:	CharacterString		
Value Measurement Unit:			
Value Domain Type:	1		
Value Domain:			
Feature Attribute Values:	Label	Code	Definition
	Unavailable	0	Unavailable
	Available	1	Available

Feature Attribute: 'gndpower'

Name:	gndpower		
Definition:	Availability of ground-power.		
Value Data Type:	CharacterString		
Value Measurement Unit:			
Value Domain Type:	1		
Value Domain:			
Feature Attribute Values:	Label	Code	Definition
	Unavailable	0	Unavailable
	Available	1	Available

Feature Attribute: 'plysttyp'

Name:	plysttyp		
Definition:	Polygonal structure type.		
Value Data Type:	CharacterString		
Value Measurement Unit:			
Value Domain Type:	1		
Value Domain:			
Feature Attribute Values:	Label	Code	Definition
	Terminal Building	1	Terminal Building
	Hangar	2	Hangar
	Control Tower	3	Control Tower
	Non Terminal Building	4	Non Terminal Building
	Tank	5	Tank
	Tree	6	Tree
	Bush	7	Bush
	Forest	8	Forest
	Earthen Works	9	Earthen Works

Feature Attribute: 'material'

Name: material

Definition: Predominant surface material of the vertical structure.

Value Data Type: CharacterString

Value Measurement Unit:

Value Domain Type: 1

Value Domain:

Feature Attribute Values:	Label	Code	Definition
	Concrete	1	Concrete
	Metal	2	Metal
	Stone or Brick	3	Stone or Brick
	Composition	4	Composition
	Rock	5	Rock
	Earthen Works	6	Earthen Works
	Wood	7	Wood

Feature Attribute: 'height'

Name: height

Definition: Maximum height of top of vertical structure.

Value Data Type: Real

Value Measurement Unit: meters

Value Domain Type: 0

Value Domain: [0.00, 999.99]

Feature Attribute Values:

Feature Attribute: 'elev'

Name: elev

Definition: Maximum elevation of the top of vertical structure (Orthometric height).

Value Data Type: Real

Value Measurement Unit: meters

Value Domain Type: 0

Value Domain: [-499.99, 8999.99]

Feature Attribute Values:

Feature Attribute: 'pntsttyp'

Name: pntsttyp

Definition: Point structure type.

Value Data Type: CharacterString

Value Measurement Unit:

Value Domain Type: 1

Value Domain:

Feature Attribute Values:	Label	Code	Definition
	Smokestack	1	Smokestack
	Powerline Pylon	2	Powerline Pylon
	Antenna	3	Antenna
	Windsock	4	Windsock
	Tree	5	Tree
	Lightpole	6	Lightpole
	Light Stanchion	7	Light Stanchion

Feature Attribute: 'lighting'

Name:	lighting		
Definition:	Obstacle lighting in conformance with Annex 14, Volume I, paragraph 6.2.		
Value Data Type:	CharacterString		
Value Measurement Unit:			
Value Domain Type:	1		
Value Domain:			
Feature Attribute Values:	Label	Code	Definition
	Non Conformant	0	Non Conformant
	Conformant	1	Conformant

Feature Attribute: 'radius'

Name:	radius		
Definition:	Radius of circle around center of obstacle including body of obstacle and associated structures including guy wires.		
Value Data Type:	Real		
Value Measurement Unit:	meters		
Value Domain Type:	0		
Value Domain:	[0.00, 999.99]		
Feature Attribute Values:			

Feature Attribute: 'marking'

Name:	marking		
Definition:	Obstacle marking in conformance with Annex 14, Volume I, paragraph 6.2.		
Value Data Type:	CharacterString		
Value Measurement Unit:			
Value Domain Type:	1		
Value Domain:			
Feature Attribute Values:	Label	Code	Definition
	Non Conformant	0	Non Conformant
	Conformant	1	Conformant

Feature Attribute: 'linsttyp'

Name:	linsttyp		
Definition:	Line structure type.		
Value Data Type:	CharacterString		
Value Measurement Unit:			
Value Domain Type:	1		
Value Domain:			
Feature Attribute Values:	Label	Code	Definition
	Power Line	1	Power Line
	Cable Railway	2	Cable Railway
	Bushes or Trees	3	Bushes or Trees
	Wall	4	Wall

Feature Attribute: 'pstdate'

Name: pstdate

Definition: Planned construction start date.

Value Data Type: Date

Value Measurement Unit:

Value Domain Type: 0

Value Domain:

Feature Attribute Values:

Feature Attribute: 'pendate'

Name: pendate

Definition: Planned construction end date.

Value Data Type: Date

Value Measurement Unit:

Value Domain Type: 0

Value Domain:

Feature Attribute Values:

Feature Attribute: 'piocdate'

Name: piocdate

Definition: Planned initial operational date.

Value Data Type: Date

Value Measurement Unit:

Value Domain Type: 0

Value Domain:

Feature Attribute Values:

Feature Attribute: 'coord'

Name:	coord
Definition:	Published reference coordinates (x/y/z or lat/long/elevation) of survey point as provided by authorized survey institution. This information is expressed using the complete resolution of the original surveyed values. Encoding: x/y/z-coordinates of survey reference point, separated by a "/". Example for Reference-Coordinates in UTM-Projection: 32499800.00/5500765.02/275.98.
Value Data Type:	CharacterString
Value Measurement Unit:	
Value Domain Type:	0
Value Domain:	maximum 64 characters
Feature Attribute Values:	

Feature Attribute: 'hdatum'

Name:	hdatum
Definition:	Full name of horizontal datum of reference coordinates.
Value Data Type:	CharacterString
Value Measurement Unit:	
Value Domain Type:	0
Value Domain:	maximum 64 characters
Feature Attribute Values:	

Feature Attribute: 'spheroid'

Name:	spheroid
Definition:	Spheroid of reference coordinate.
Value Data Type:	CharacterString
Value Measurement Unit:	
Value Domain Type:	0
Value Domain:	maximum 64 characters
Feature Attribute Values:	

Feature Attribute: 'vdatum'

Name: vdatum

Definition: Name of vertical datum of reference coordinates.

Value Data Type: CharacterString

Value Measurement Unit:

Value Domain Type: 0

Value Domain: maximum 32 characters

Feature Attribute Values:

Feature Attribute: 'project'

Name: project

Definition: Full name of projection of reference coordinates.

Value Data Type: CharacterString

Value Measurement Unit:

Value Domain Type: 0

Value Domain: maximum 32 characters

Feature Attribute Values:

Feature Attribute: 'geopoly'

Name: geopoly

Definition: Polygonal object.

Value Data Type: GM_Polygon

Value Measurement Unit:

Value Domain Type: 0

Value Domain:

Feature Attribute Values:

Feature Attribute: 'geoline'

Name: geoline

Definition: Line object.

Value Data Type: GM_LineString

Value Measurement Unit:

Value Domain Type: 0

Value Domain:

Feature Attribute Values:

Feature Attribute: 'geopnt'

Name: geopnt

Definition: Point object.

Value Data Type: GM_Point

Value Measurement Unit:

Value Domain Type: 0

Value Domain:

Feature Attribute Values:

Default Values

If no default values are given in the definition of the attributes, then values given in Table 4-11 must be used.

Table 4-11. Default values for aerodrome feature attributes

Attribute Format	Null	Unknown	Not Applicable	Not Entered
CharacterString	"\$Null"	"\$UNK"	"\$NA"	"\$NE"
Integer	-32768	-32767	-32765	-32764
Real	-32768.00	-32767.00	-32765.00	-32764.00
Date	00-00-0000	00-00-0001	00-00-0002	00-00-0003
Time	25:00:00	26:00:00	27:00:00	28:00:00

Supplemental Features

The feature catalogue provides the mandatory and optional features and feature attributes that may be included in the data set. While it is expected that these will satisfy most applications, supplemental features and feature attributes may be provided.

For supplemental features, specific rules concerning feature naming convention and mandatory information are used. Every supplemental feature should be described in a data interchange report file. For supplemental features, the following information is required: feature name, feature description, geometry type, derivation method, and data capture rule.

For supplemental features and feature attributes, the feature catalogue must be amended using ISO 19131.

Supplemental Feature Attributes

For supplemental features, the attributes listed in Table 4-12 must be provided.

Table 4-12. Required attributes for supplemental aerodrome features

Attribute	Name	Description
Feature type	featype	Textual description of the feature type
Airport ID	idarpt	ICAO location indicator
Object ID	idobj	Unique identifier for the feature
Data Source Identifier	source	Name of entity or organization that supplied data. In case of initial data origination, name of data originator
Geometry	geopnt, geoline, geopoly	Point feature, line feature or polygonal feature, respectively
Horizontal Accuracy	hacc	Horizontal accuracy of the recorded position
Horizontal Confidence Level	hconf	The probability that the recorded position is within the stated horizontal accuracy of the true position
Vertical Accuracy	vacc	The vertical accuracy of the recorded elevation
Vertical Confidence Level	vconf	The probability that the recorded position is within the stated vertical accuracy of the true position
Horizontal resolution	hres	Horizontal resolution of the recorded position
Integrity	integr	Integrity of data is the degree of assurance that the data and its value have not been lost nor altered since the data origination or authorized amendment
Time Stamp	revdate, revtime	Time of origination or of last data revision

When there is a desire to specify feature attributes beyond those listed in Table 4-12 for supplemental features, the following rules concerning attribute naming conventions must be followed.

- » supplemental feature attribute names should end with “_s” for *supplemental*.
- » no duplicate names
- » only letters from the U. S. ASCII code (a..z)
- » maximal eight letters
- » only lower-case letters

For these additional feature attributes, attribute types must be one of the following:

- » CharacterString (not longer than 255 characters)
- » Integer
- » Real
- » Date
- » Time

Also, for these additional feature attributes, the following information must be provided:

- » name of the attribute
- » description of the attribute
- » feature type
- » fixed value for the attribute
- » maximum number of characters (for attributes of type CharacterString)
- » coding and labels (possible entries as defined by a code list)
- » units of measurement (e.g. meters, degree, etc.)
- » domain range (minimum and maximum value)

All codes required for additional features, attributes, and/or code lists must adhere to the following rules:

- » code values must be described in the feature catalog
- » codes should be of type CodeList
- » supplemental attribute codes must be greater than 100
- » no duplicate codes

Finally, all labels required for any additional features, attributes, and/or code lists must adhere to the following rules:

- » label values must be described in the feature catalog
- » labels should be of type CodeList
- » supplemental attribute labels must end with the string “ SUPP”
- » no duplicate labels

4.3.5 Reference Systems

The DPS must include information that defines the reference systems used in the data product. This must include the following:

- » the spatial reference system

Example: Horizontal locations are provided in decimal degrees with respect to latitude and longitude (WGS-84); vertical values are provided in meters with respect to MSL (EGM-96).

- » the temporal reference system

Example: Time and date values are provided with respect to UTC and the Gregorian calendar.

The spatial reference system used must be a reference system as defined in Annex 15. A coordinate reference system allows for the definition of horizontal and vertical datums. The horizontal datum must be WGS-84, and the vertical datum should be MSL using an appropriate geoid model such as EGM-96.

The Gregorian calendar and Coordinated Universal Time (UTC) must be used as the temporal reference system for aerodrome mapping data products that comply with this standard.

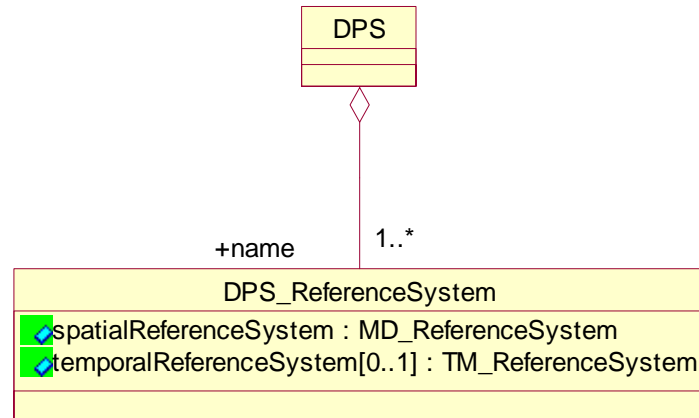
Reference system identifiers must identify the reference systems. These may take the form of either:

- » the names of the reference systems (e.g. WGS-84), or
- » codes for the reference systems, and a statement of the source of those codes (e.g. Code EPSG::4723 for WGS-84 [E. Petroleum Survey Group], Code WGE for WGS-84 [National Geospatial-Intelligence Agency and ARINC-424])

Requirements for identifying the reference system for aerodrome mapping data products are listed in Table 4-13, while the UML model is given in Figure 4-38.

Table 4-13. Reference system identification for aerodrome mapping data

Item Name	Definition	Obligation/Condition	Multi.	Data Type	Domain
spatialReferenceSystem	identifier of spatial reference system	M	1	Class	MD_Reference System
temporalReferenceSystem	identifier of temporal reference system	O	1	Class	TM_Reference System

**Figure 4-38. UML model for reference system information for aerodrome mapping data**

4.3.6 Data Quality

Information about the quality of available aerodrome mapping data sets is vital to the process of selecting a data set in that the value of data is directly related to its quality. For the purpose of evaluating the quality of a data set, clearly defined procedures must be used in a consistent manner. Complete descriptions of the quality of a data set will encourage the sharing, interchange and use of appropriate geographic data sets. This enables data producers to express how well their product meets the criteria set forth in its product specification and data users to establish the extent to which a data set meets their requirements.

For each aerodrome feature, this document provides a set of quality parameters. These are listed in the feature catalogue and include:

- » Vertical accuracy
- » Horizontal accuracy
- » Vertical resolution
- » Horizontal resolution
- » Name of entity or organization that supplied data
- » Data integrity supporting the end-to-end quality system from provider to end-user
- » Date of last revision or generation of data source

Data files must be protected by CRC (see Annex 15) to ensure that data is not corrupted during the interchange process. Each manufacturer, or customer, in the distribution chain is responsible for verifying that data is written and received using a CRC.

Requirements for identifying the quality of aerodrome mapping data products are listed in Table 4-14, while the UML model is given in Figure 4-39. For a more general discussion about quality conformance and reporting, refer to Appendix C of this document.

Table 4-14. Quality identification for aerodrome mapping data

Item Name	Definition	Obligation/Condition	Multi.	Data Type	Domain
dataQuality	quality information concerning the data product	M	N	Class	DQ_DataQuality

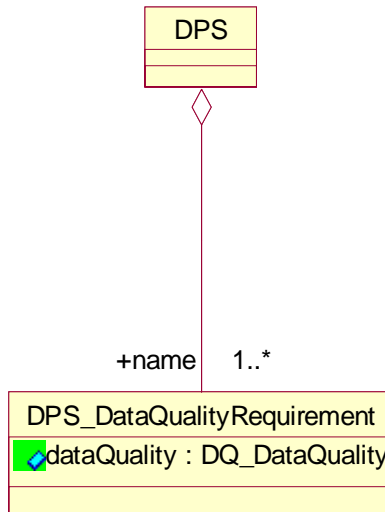


Figure 4-39. UML model for quality information for aerodrome mapping data

4.3.7 Data Capture

The scope of this data interchange standard does not include the process of data capture, although it is recognized that the content and the quality of an aerodrome mapping data product is significantly correlated with the process of data capture. This document, however defines data capture rules for certain features.

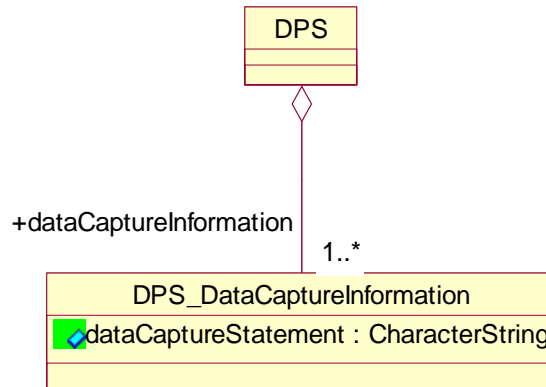
This DPS defines attributes and metadata that enable the results of the data capture methods to be communicated for aerodrome mapping data. In addition, the way in which data concerning real-world geo-spatial phenomena and characteristics of real-world phenomena are captured must be specified. The data to be included in this section of the DPS must include a data capture statement that must be a general description of the process for the capture of the data.

Conformance quality levels may need to be given for intermediate data, which may be required for the production of the data. Requirements for identifying the data capture method for aerodrome mapping data are listed in Table 4-15, while the UML model is given in Figure 4-40.

Table 4-15. Data capture identification for aerodrome mapping data

Item Name	Definition	Obligation/Condition	Multi.	Data Type	Domain
dataCaptureStatement	general description of the process for the capture of the data	M	1	CharacterString	Free text

Example: The DIA data set has been derived from satellite imagery and digitized using ground control points to ensure that stated accuracies were met.

**Figure 4-40. UML model for data capture information for aerodrome mapping data**

4.3.8 Data Maintenance

Aerodrome mapping data products are increasingly being used in dynamic environments: shared, interchanged, and used for purposes that require both accuracy and temporal relevance. Continuous maintenance and timely updates of aerodrome mapping data is vital to the process of end-user applications.

Requirements for identifying the maintenance method for aerodrome mapping data are listed in Table 4-16, while the UML model is given in Figure 4-41. For a more general discussion about maintenance, refer to Appendix D of this document.

Table 4-16. Maintenance identification for aerodrome mapping data

Item Name	Definition	Obligation/Condition	Multi.	Data Type	Domain
Maintenance and update frequency	Frequency with which changes and additions are made to the product	M	1	Class	MD_MaintenanceFrequencyCode <<CodeList>>

Example: MD_MaintenanceFrequencyCode 001, repeatedly and frequently updated.

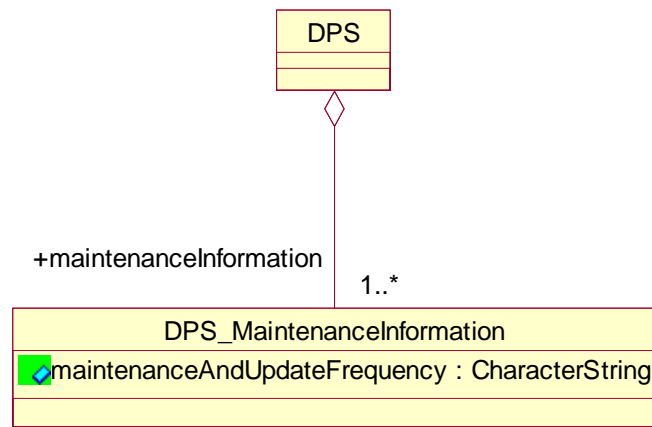


Figure 4-41. UML model for maintenance information for aerodrome mapping data

4.3.9 Portrayal

The aerodrome mapping DPS may provide information on how the data is to be presented as graphic output. If portrayal information is provided, applicable requirements are given in Table 4-17, while the UML model is given in Figure 4-42.

Table 4-17. Portrayal information for aerodrome mapping data

Item Name	Definition	Obligation/Condition	Multi.	Data Type	Domain
portrayalCatalogCitation	Bibliographic reference to the portrayal catalog	C/if provided	N	Class	CI_Citation

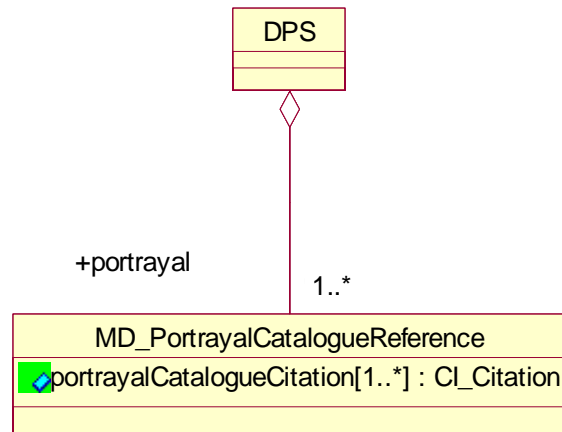


Figure 4-42. UML model for portrayal information for aerodrome mapping data

4.3.10 Data Product Delivery

This DPS contains no specific requirements for data product delivery, however, a compliant physical implementation of the DPS should identify the following elements: format name, version, specification, file structure, language, character set, units of delivery, transfer size, medium name, and other delivery information.

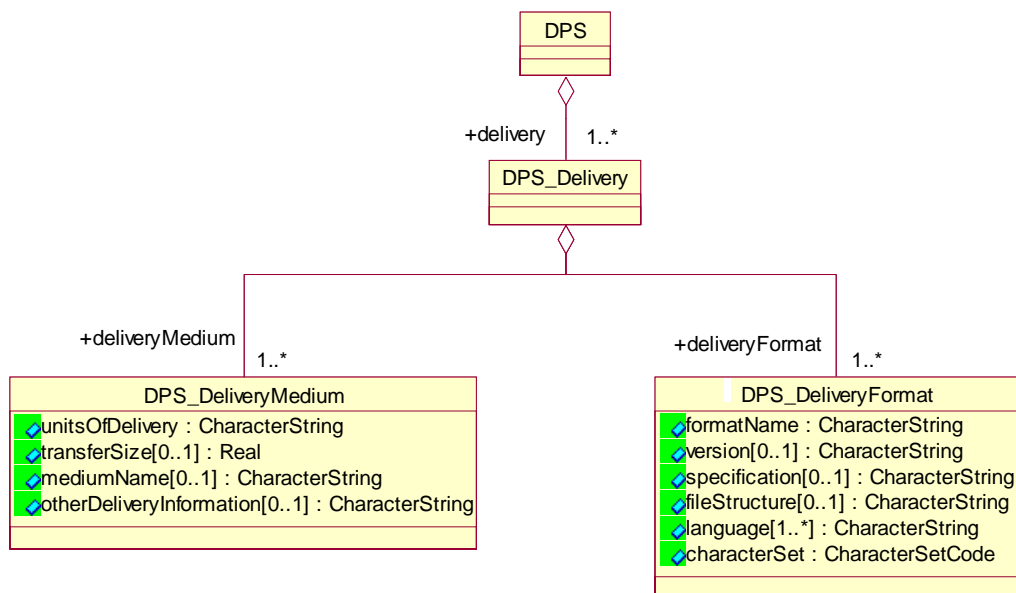
If data product delivery information is provided, applicable requirements are given in Tables 4-18 and 4-19, while the UML model is given in Figure 4-43.

Table 4-18. Delivery format information for aerodrome mapping data

Item Name	Definition	Obligation/Condition	Multi.	Data Type	Domain
formatName	name of the data format	M	1	Character String	Free text
Version	version of the format (date, number, etc)	O	1	Character String	Free text
specification	name of a subset, profile, or product specification of the format	O	1	Character String	Free text
fileStructure	structure of delivery file	O	1	Character String	Free text
Language	language(s) used within the data set	M	N	Character String	ISO 639-2, other parts may be used
characterSet	full name of the character coding standard used for the data set	O	1	Class	MD_CharacterSetCode

Table 4-19. Delivery medium information for aerodrome mapping data

Item Name	Definition	Obligation/Condition	Multi.	Data Type	Domain
unitsOfDelivery	description of the units of delivery (e.g. tiles, layers, geographic areas)	M	1	Character String	Free text
transferSize	estimated size of a unit in the specified format, expressed in Mbytes	O	1	Real	>0
mediumName	name of the data medium	O	1	Character String	Free text
otherDeliveryInformation	other information about the delivery	O	1	Character String	Free text

**Figure 4-43. UML model for delivery information for aerodrome mapping data**

4.3.11 Additional Information

This Chapter of the DPS may include any other aspects of the data product not provided elsewhere in this specification.

4.3.12 Metadata

The metadata requirements for AMDB are derived from ISO 19115. Metadata is classified as identification information, quality information, maintenance information, reference system information, distribution information, extent information, and citation information. The UML models for the required metadata are given in Figures 4-44 through 4-51. Descriptions of metadata elements and code lists are given in Appendix F [Metadata Elements] and G [Metadata Code Lists and Enumerations], respectively.

The AMDB Model integration diagram and the AMDB Application Schema diagram are shown in Figure 4-26 and Figure 4-27, respectively.

Figure 4-44 defines the class MD_MetaData, which is a composition of all the metadata entities that are required to support the interchange of aerodrome mapping data products.

Note: the following attributes are not part of ISO 19115, but are required by this interchange standard: dataIntegrity, qualityClassification, horzUnit, vertUnit, and MD_QualityClassCode.

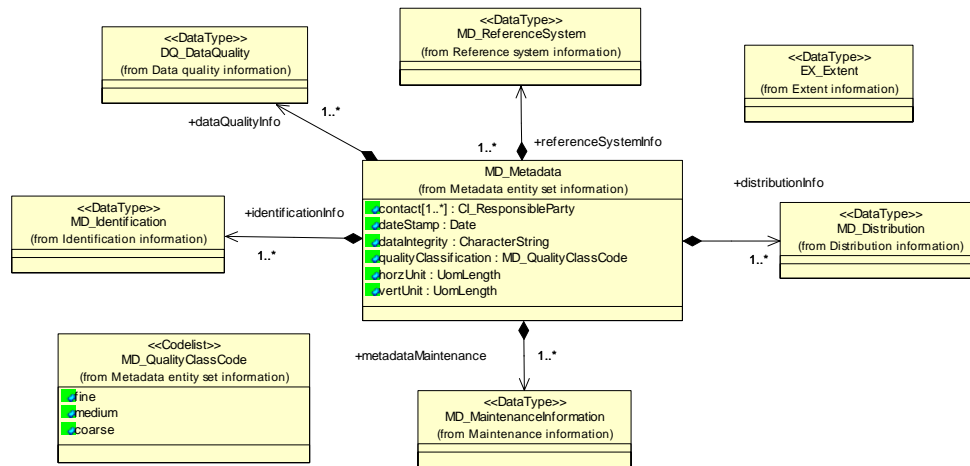


Figure 4-44. Aerodrome mapping metadata – overview

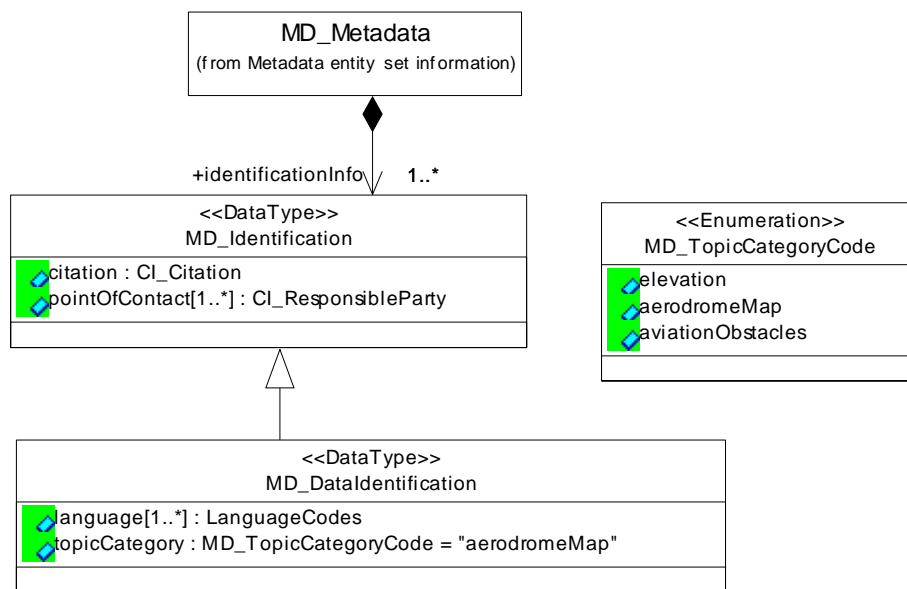


Figure 4-45. Aerodrome mapping metadata – identification

Figure 4-46 defines the metadata required to give an assessment of the quality and provide lineage information for aerodrome mapping data.

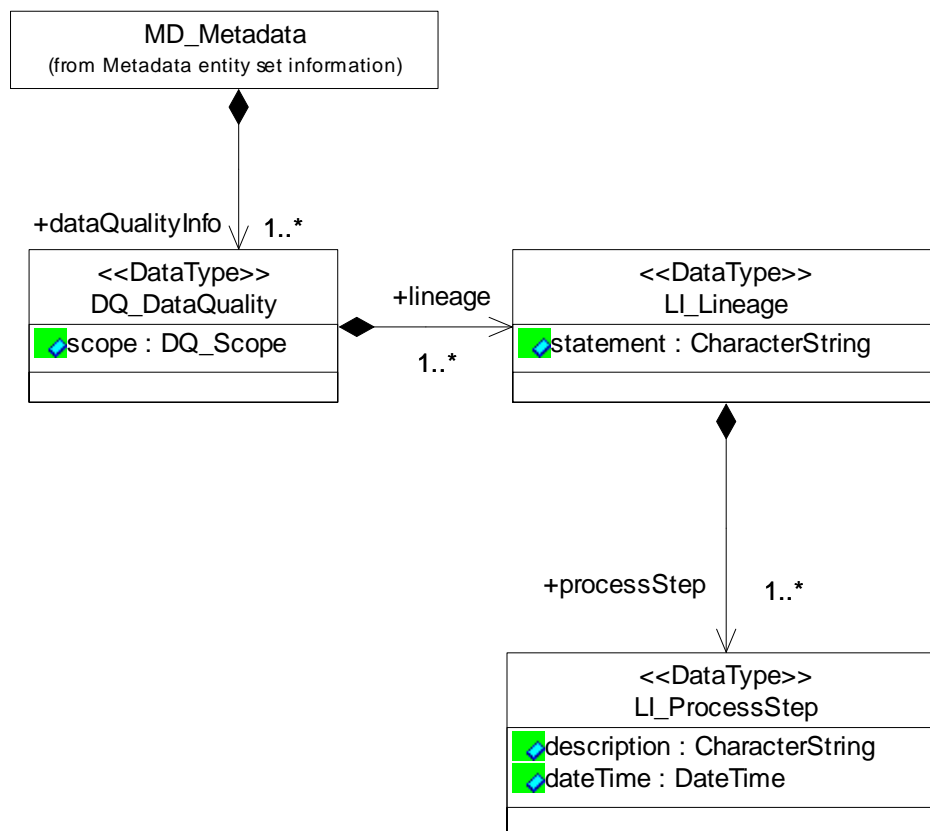


Figure 4-46. Aerodrome mapping metadata – quality

Figure 4-47 defines the metadata required to describe the maintenance and update practices for aerodrome mapping data.



Figure 4-47. Aerodrome mapping metadata – maintenance

Figure 4-48 defines the metadata required to describe the spatial reference system used for aerodrome mapping data.

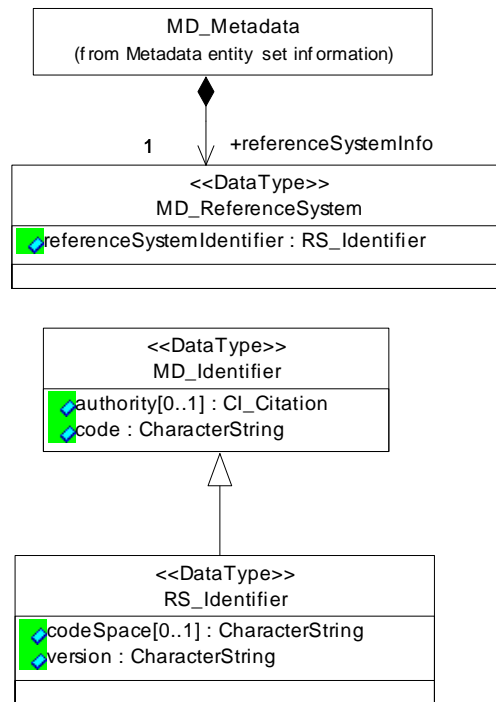


Figure 4-48. Aerodrome mapping metadata – reference system

Figure 4-49 defines the metadata required to describe distribution information for aerodrome mapping data.

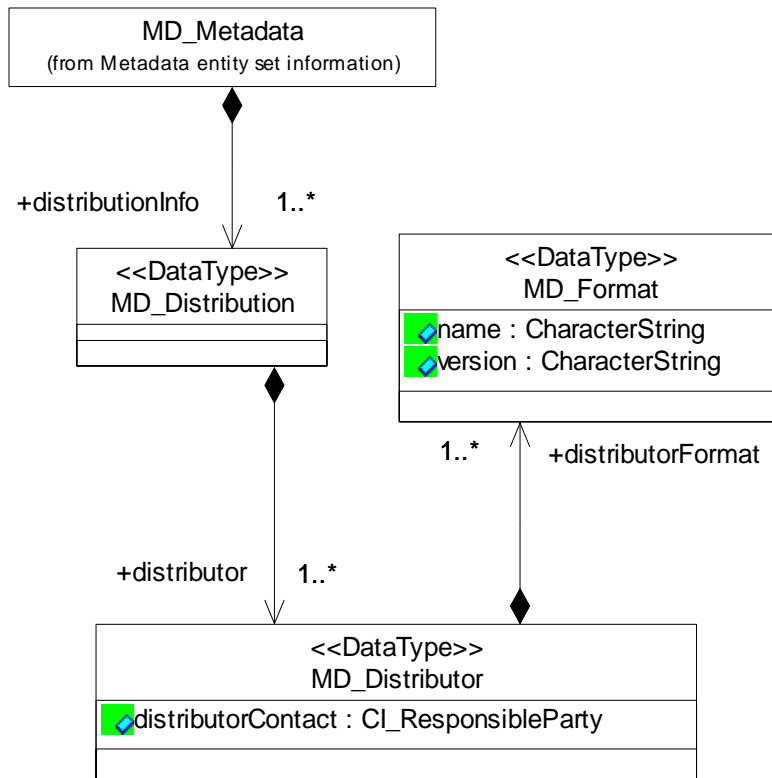


Figure 4-49. Aerodrome mapping metadata – distribution

Figure 4-50 defines the metadata required to describe the spatial extent of aerodrome mapping data.

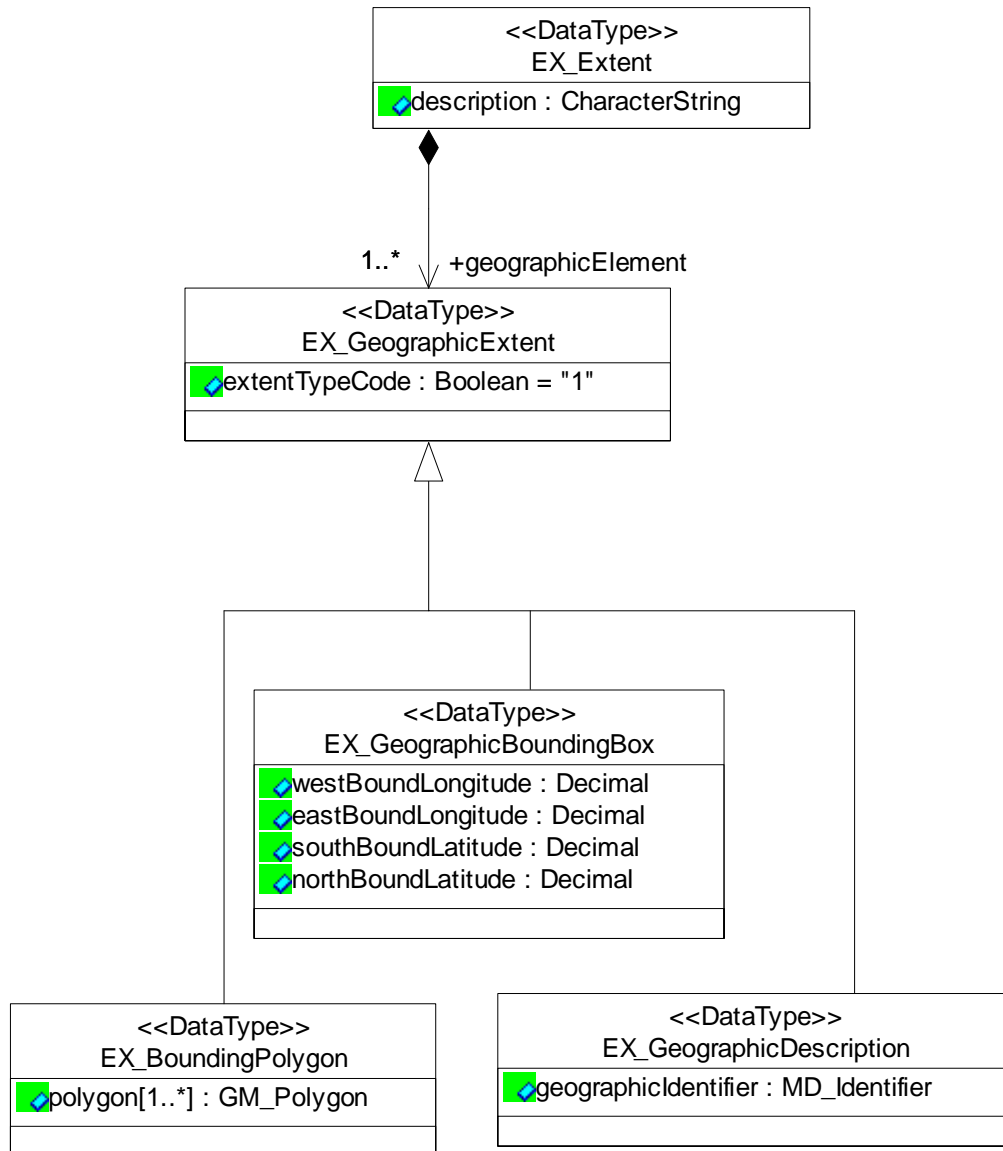


Figure 4-50. Aerodrome mapping metadata – spatial extent

Figure 4-51 defines the metadata describing authoritative reference information, including responsible party and contact information, for aerodrome mapping data.

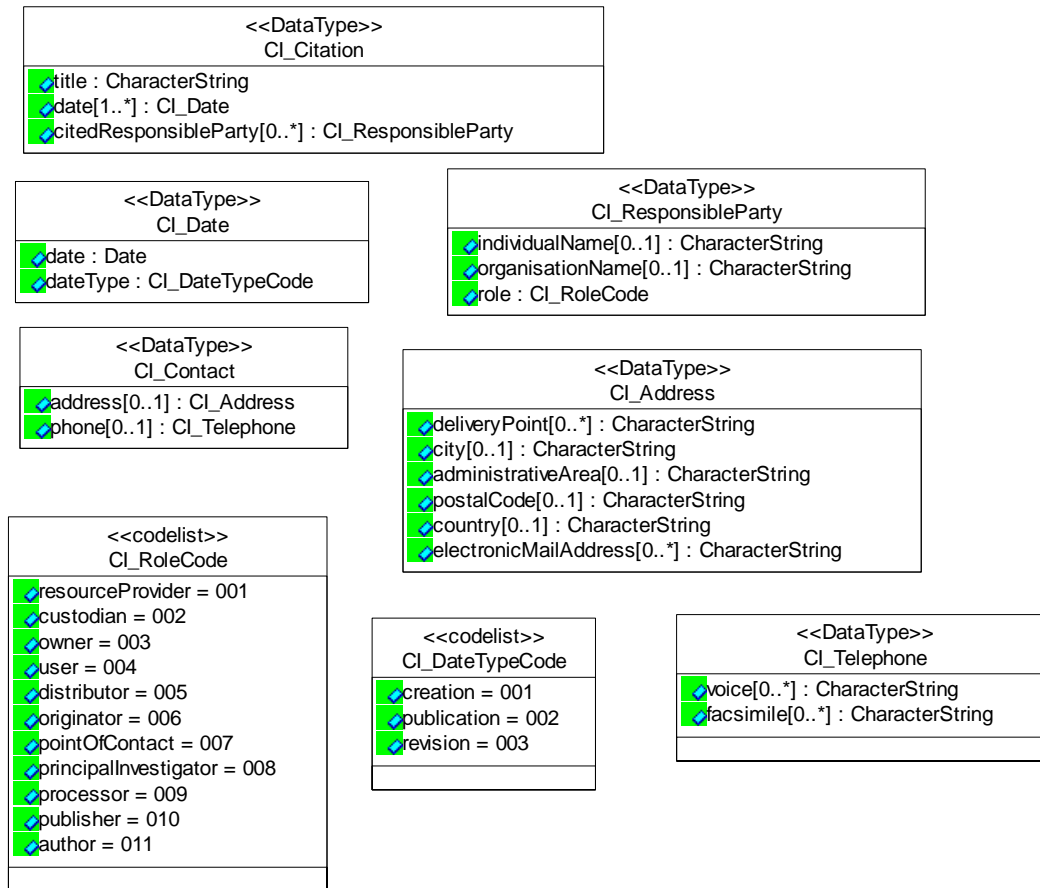


Figure 4-51. Aerodrome mapping metadata – citation and responsible party

Appendix A: Applications

A.1 Terrain and Obstacle Data

A.1.1 Introduction

There is an emerging need for the development and provision of electronic (i.e., digital) aviation databases. These new databases are required to support the implementation of communications, navigation and surveillance/air traffic management (CNS/ATM) systems and other systems as appropriate. This appendix presents insight from the ATM users' perspective as to why these new databases are required, as well as to describe some of the emerging operational applications that can be supported by these new databases. Quality requirements for each application (in terms of accuracy, resolution, end-to-end system integrity, and other attributes) are presented in this appendix.

A.1.2 Background

Overview of Terrain and Obstacle Aviation Database Applications

Within the last several years, there has been a growing awareness by many within the aviation community that digital, computer-based avionics can be used to provide the flight crew with additional information to help them make better, more balanced decisions. Situational awareness is the term that best describes the ability of pilots to know what is going on in relationship to their aircraft and their external environment. The underlying philosophy is to make additional but relevant information available to pilots to assist them in their decision-making process, such as knowledge of one's location with respect to terrain or obstacle hazards. In this context, separation assurance is defined within a broad context as being separation from any hazard *external* to an aircraft including terrain and obstacles, adverse weather, and wake vortex hazards, as opposed to just proximate traffic.

While every aircraft cockpit provides some level of situational awareness, for example, pilots can look outside the windshield and see rising terrain, this is not enough! It is necessary to find ways to take the raw data received through various CNS data links, as well as from onboard databases, and display it as processed *information* to the flight crew in a standardized, user-friendly, intuitively-obvious fashion. New air carrier and top-of-the-line general aviation aircraft, with their active matrix liquid-crystal flat-panel displays, are already heading in this direction. This is not yet so, however, at the lower end of the general aviation market, although there are innovations appearing there as well. Portable and installed displays will enable this functionality. In the end state, the CNS/ATM systems necessitate that all airspace users, including general aviation, have enhanced (and affordable) situational awareness information. This, along with a mature free flight separation assurance policy and procedures, will be pivotal as migration from existing airspace-based separation philosophy to one that is fully trajectory-based.

Figure A-1 illustrates what a cockpit-centred situational awareness architecture might look like that would support the CNS/ATM systems. At the heart of this architecture is an advanced data management computer system. The breakthrough needed is a means to make reliable computer systems for the cockpit that incorporate the concept of partitioned software applications, in essence, modular application-specific software that is affordable for all classes of airspace users.

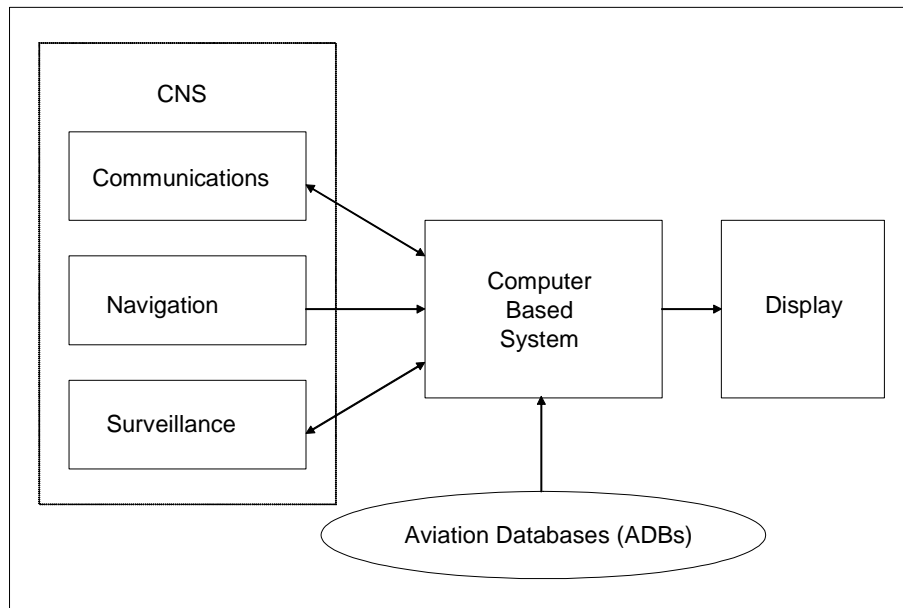


Figure A-1. Simplified version of one possible advanced CNS cockpit architecture

To support the above notional avionics architecture, various digital aviation databases need to be developed. For example, terrain and obstacle databases can support a variety of new cockpit-based operational applications, including two-dimensional (2-D), three-dimensional (3-D), and four-dimensional (4-D) (which includes time) predictive controlled flight into terrain (CFIT) prevention systems and Approach and Landing Accident Reduction (ALAR) systems.

Additional operational applications are also possible, such as providing for an in-flight determination of “drift-down” requirements; one-engine inoperative departure climb profiles at specific aerodromes; aerodrome surface movement area portrayals for situational awareness and runway incursion protection; and procedure design including curved approach procedures. All these are examples of where these new databases, along with highly accurate aerodrome portrayals, go well beyond a simple safety case. The “core” aviation databases include navigation, terrain, obstacles, aerodrome maps, airspace, and noise abatement procedures.

A.1.3 Air Navigation Applications that use Terrain and Obstacle Data Sets

Cockpit-based applications

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

Ground-based or ground-use applications

- Minimum Safe Altitude Warning (MSAW) system;

- Instrument procedure design (including circling procedures);
- Contingency procedure analysis and determinations;
- Flight simulator; and
- Aeronautical chart production.

A.1.4 Ground Proximity Warning System (GPWS)

Operational Concept

A digital terrain and obstacle database could support a variety of new cockpit-based CFIT prevention applications, including two-dimensional (2-D), three-dimensional (3-D), and four-dimensional (4-D, which includes time) predictive controlled flight into terrain protection. The databases may also contribute to reducing approach and landing accidents that account for approximately fifty-six percent of the world's jet fleet accidents.

Ground Proximity Warning System (GPWS) technology with forward-looking capabilities provides flight crew with information of impending dangerous terrain and obstacles. This results in earlier alerts and more time to take appropriate corrective action. New multifunction displays, which should become affordable for airspace users, are expected to merge terrain and obstacle databases and aircraft GNSS and flight management guidance system sensor data. Current certified terrain warning systems use digitized terrain data intended for advisory use only since these data sets are not certified for navigation as they lack stringent data quality requirements (accuracy, resolution and integrity).

Benefits

CFIT and approach and landing accidents represent a significant percentage of all aviation accidents. Consequently, there is a significant safety benefit made possible by developing a comprehensive terrain and obstacle database.

A.1.5 En-route “Drift-Down” Procedures

Operational Concept

As aviation moves forward to use Area Navigation (RNAV), with point-to-point direct routings predicated on navigation systems with specified Required Navigation Performance (RNP), more aircraft will likely fly off-airways. Many of these routes will overfly mountainous terrain, or areas such as the Greenland Ice Cap. Occasional re-routings take commercial aircraft on routes where a one-engine inoperative “drift-down” (or for some other reason), may require the aircraft to descend over mountainous terrain. In some light twin-engine aircraft, one-engine inoperative cruise flight may be performance limited such that the aircraft is unable to sustain flight above the Minimum Obstacle Clearance Altitude (MOCA). Consequently, without any outside help, pilots need to quickly and accurately calculate their best “escape” route to avoid high terrain and/or to maintain the necessary terrain and obstacle clearance.

Benefits

This operational application has both a safety as well as an operational flexibility component.

A.1.6 En-route Emergency Landing Location Selection

Operational Concept

During an in-flight emergency, especially in general aviation aircraft, selection of an acceptable emergency landing site can often mean the difference between an aircraft sustaining only minor or no damage, versus sustaining catastrophic damage. The risks are great when an aircraft must land

immediately for any reason when flying at night or over unfamiliar territory. Under these conditions, both the World Aeronautical Chart (WAC) – ICAO and the Aeronautical Chart – ICAO (both carried by VFR pilots) are of limited use in identifying potential safe landing sites, especially if the aircraft is beyond its best gliding distance from the nearest suitable aerodrome. This situation is compounded when flying during instrument flight conditions. Under such circumstances, a high resolution, digital image, containing vegetation and cultural features, overlaid onto a terrain and obstacle database could assist pilots in identifying the safest location for a forced, emergency landing.

For example, in a composite graphical portrayal, a colour rendering of the vegetation cover database could assist in an emergency landing site selection. With minor additional software feature enhancements, an aircraft's drift-down performance, its glide path and minimum landing field requirements, could be continuously recalculated, then displayed graphically along with the vegetation and landing site image as a vector-based overlay. The effect would be to give pilots continuous information on the availability of forced landing areas. Such a software option that uses basic terrain and obstacle data sets described in this document would be especially helpful when flying over unfamiliar territory, at night, during climb-out or en route and under the instrument meteorological conditions (IMC).

Additionally, present generation of aeronautical charts does not distinguish among the various classes of foliage, or forestry land densities. When vegetation appears on these charts, it is shown as a homogenous blanket within a well-defined boundary. Modern spectral imagery techniques can differentiate between various ground cover types. These imagery sources, however, do not reveal the relative vertical heights or densities of the composition layer.

Benefits

The aviation community could benefit from this application as it could produce safety benefits especially when flying at night or IMC, by expanding emergency landing options.

A.1.7 Synthetic vision

It should be noted that at the time of writing this document, the quality requirements needed to support synthetic vision in terms of accuracy, resolution, integrity and timeliness had not been determined.

Operational Concept

An aircraft's ability to conduct flight operations in today's airspace environment is dependent upon a number of factors. Among these, reduced visibility is a significant factor. As weather and visibility conditions deteriorate, it is increasingly difficult to conduct flight operations in the same manner and at the same rate as in visual meteorological conditions (VMC). While today's technology provides solutions to many of the problems caused by low visibility, the potential now exists to provide information well beyond what the pilot is able to see even on a clear day. The operational concept is to create a *virtual visual environment* that all but eliminates reduced visibility as a significant factor in flight operations, and enhancing what the pilot can see even in the best of visibility conditions. A virtual visual environment can be described in terms of its components and the operational flight phases it supports.

The synthetic vision "virtual visual environment" is composed of three components: an enhanced intuitive view of the flight environment, hazardous terrain and obstacle detection and display, and precision navigation guidance. The intuitive view is derived from terrain data base background images with multi-system information superimposed or integrated over them. This information is comprised of tactical information typically found on a primary flight display as well as strategic information typically found on a navigation display. Since cluttered displays are undesirable, pilots will need to choose certain layers so that the system and its displays will be able to present an intuitive and simple-to-comprehend visual portrayal.

Required system redundancy and reliability of the synthetic vision system will be a function of the criticality of the flight operations being supported. Reversionary modes providing graceful degradation in

performance along with various levels of redundancy will be needed. In addition, fail passive and fail operational capabilities will need to be an integral part of the overall system. Subsystem redundancies and cross-checking will be needed to ensure integrity of flight critical information. It is imperative that no single failure be allowed to cause a flight safety hazard. The enhanced intuitive view will also be designed to minimise nuisance alerts, the effects of spurious data, and other anomalies.

Significant (aviation hazardous) obstacle avoidance is a prerequisite for safe flight operation in all phases of flight. Consequently, synthetic vision systems will display and appropriately highlight all terrain and obstacles that present a potential hazard to the aircraft during each phase of flight. Features that need to be displayed include terrain, vegetation, temporary and permanent obstacles, including “movable” obstacles.

Database integrity will be a major parameter of the system. Terrain and obstacle data must be of required accuracy, resolution, and integrity to support the precision navigation. By combining sensor and data base information of the accuracy and integrity required to support flight operations down to an precision approach and landing Category IIIB minima may be achievable.

Benefits

Current technology and systems allow flight crews to perform “all-visibility” en-route flight operations as well as low-visibility approaches and landings to appropriately equipped runways. Synthetic vision systems will go beyond this present capability, and will further increase pilot’s situational awareness and performance by integrating existing and new systems into a virtual visual environment. Such an expanded capability will enhance safety and provide operational benefits. All flight phases including ground operations, departure, en-route, arrival and landing will be impacted. Benefits derived from the individual components will be enhanced as a result of the integration of the individual technologies. Synthetic vision systems are expected to emulate day visual flight operations at night and in limited visibility conditions. Using synthetic vision systems, the overall accident rate and hull loss rate is expected to become that of day visual flight operations. Some of the expected safety benefits include a reduced risk of a controlled flight into terrain accident, aerodrome runway incursion risk reduction, improved pilot situational awareness, improvement in unusual attitude/upset recovery, improved non-normal situation response, and improved compliance with air traffic clearances and instructions.

As beneficial as the above safety enhancements might be, the economic nature of the aviation industry requires that these safety benefits be coupled with increased operational benefits so that user community support is achieved early-on in the development and implementation process. Early-on support will help ensure timely participation of private sector in the development, certification, and implementation phases of this emerging technology.

A.1.8 Minimum Safe Altitude Warning (MSAW) System

Operational Concept

Today, the Minimum Safe Altitude Warning (MSAW) digital terrain and obstacle maps function is a last line of defence “safety net” in conjunction with aerodrome (terminal area) surveillance radar. The purpose of these digital maps (and supporting software) is to alert the controller (who then alerts pilot through radio communication) that an altitude deviation has been observed which may impose a safety of flight hazard with nearby terrain and/or obstacles. MSAW works by having the ground-based radar system monitor the flight paths of aircraft equipped with encoding transponders to ensure adequate terrain and obstacle separation. This is accomplished by comparing the flight paths with a three-dimensional grid map stored in the ground-based radar system. When a potentially unsafe condition is detected, both a visual and an aural alarm signal alert the controller. The controller then alerts the pilot by radio of an unsafe condition. An opportunity exists to incorporate this system with other alternative surveillance systems such as Automatic Dependent Surveillance-Broadcast (ADS-B), that also uses higher quality terrain and obstacle data sets.

Benefits

This operational application is a flight critical safety application -- the “last line of defence”. Air traffic relies on this data to provide flight crews with guidance pertaining to safe terrain and obstacle avoidance. Comprehensive terrain and obstacles data sets of higher accuracy in the aerodrome vicinity may provide increased protection against approach and landing accidents and CFIT.

A.1.9 Instrument Procedure Design (including circling procedures)

Operational Concept

Procedures design include airways, standard instrument departures and arrivals, feeder routes, instrument approach and missed approach procedures and circling approach procedures. Procedure design specialists use data describing both man-made and natural (terrain) obstacles and apply obstacle clearance criteria to calculate minimum altitudes for each procedure segment. Procedure specialists also evaluate various other ancillary air traffic systems to verify that the required obstacle clearances are met.

Benefits

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

A.1.10 Contingency Procedure Analysis and Determinations

Operational Concept

Aircraft operators are required to follow established departure and arrival procedures approved by the civil aviation authorities that are calculated on all-engine operational condition. However, according to the provisions set forth in Annex 6, aircraft operators are responsible for performing take-off analysis and determinations of contingency procedures in the case of emergency to ensure safe take-off (departures) and missed approach procedures for each aircraft type in their fleet flying at a specific aerodrome.

Annex 6, 5.2.8: “*Take-off*: The aeroplane must be able, in the event of a critical power-unit failing at any point in the take-off, either to discontinue the take-off and stop within the accelerate-stop distance available, or to continue the take-off and clear all obstacles along the flight path by an adequate margin until the aeroplane is in a position to comply with 5.2.9.”

Note: Annex 6, 5.2.9, describes the requirements of the en-route portion of the flight.

The Aeroplane Flight Manual (AFM) provided by the aircraft manufacture contains the procedures and aircraft performance data needed to calculate a take-off weight to clear all obstacles by an “adequate margin” during the take-off. There are many variables used in the calculations including the aerodrome altitude and temperature, runway declared distances and obstacle location and height, to name a few. Take-off analyses are performed to see if the departure can be flown with one engine not operating. If the weight penalties are too severe to clear obstacles with the required margin at the authority prescribed procedure, the aircraft operator creates contingency (engine-out) procedures applicable at that aerodrome for the specific aircraft type.

Currently, aircraft operators use Aerodrome Obstacle Chart - ICAO, Types A, B and C, and when available topographic maps to obtain the best and most accurate available obstacle and terrain data for an aerodrome. An electronic digital terrain and obstacle data sets would eventually replace existing hard copy products.

Benefits

Aircraft operators would greatly benefit by having an up-to-date, digital, standardized terrain and obstacle data sets. Aircraft operators will improve their contingency procedure analysis and determinations,

increase safety, and maximise their take-off weights by utilising a comprehensive digital obstacle and terrain data sets.

A.1.11 Flight Simulators

Operational Concept

This operational application would provide flight crews with a graphical “virtual reality” portrayal of the geographic areas containing terrain and obstacle data collected in a terminal airspace. These portrayals could be used in ground-based flight simulators, including PC-based systems. In addition to terrain and obstacle data, aerodrome mapping data containing surface movement areas as well as ramp areas, terminal buildings, etc., could be included as graphical displays in these flight simulation systems.

Benefits

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

A.2 Air Navigation Applications that use Aerodrome Mapping Data

A.2.1 Introduction

An overview of the types of applications that may make use of aerodrome mapping data sets are provided in this appendix. These application categories have been used to generate user requirements for the content, origination, publication, updating, and enhancement of the aerodrome mapping data, as they have been included in the main body of this document.

Many of the applications described herein are intended primarily to improve the user’s situational awareness and/or to supplement surface navigation, thereby increasing safety margins and operational efficiency. Because the human factors term “Situational Awareness” is somewhat general, more specific operational benefits will be listed for each application. All of these specific benefits can be considered as contributing to overall improved users situational awareness (e.g., pilots, controllers, aerodrome planners, and managers).

As per definition, “Situational Awareness (SA) is the perception of elements in the environment, the comprehension of their meaning, and the projection of their status into the near future”.¹

For pilots, the notional concept is that situational awareness includes three fundamental elements: factors affecting the pilot’s physical and emotional state; factors affecting the aircraft and its airworthiness; and all factors *external* to the aircraft. These external factors include situational awareness of where you are with respect to terrain and obstacle hazards, adverse weather, traffic, and wake vortex hazards.

A.2.1.1 Related ICAO, EUROCAE, and RTCA activities

ICAO has defined operational requirements for Advanced Surface Movement Guidance and Control Systems (A-SMGCS)² that specify what is required to support safe, orderly, and expeditious movement of aircraft and vehicles at aerodromes under all visibility conditions, traffic densities, and aerodrome layouts.

¹ Endsley, M., “Design and Evaluation for Situation Awareness Enhancement”, Proceedings of the 32nd Annual Meeting of the Human Factors Society, pp. 97-101, Santa Monica, CA, 1988.

² “Advanced Surface Movement Guidance and Control Systems (A-SMGCS) Manual” Doc 9830, ICAO, First edition 2004.

These requirements were written to ensure standardization and safety with respect to global interoperability.

Specific recommendations are made in ICAO A-SMGCS Manual (Doc 9830) for improving aerodrome surface operations. Some of these are listed below:

- Improved means of providing situational awareness information to pilots, controllers and vehicle operators
- Clearly defined roles and responsibilities that eliminate procedural ambiguities that lead to operational errors and deviations
- Improved guidance and procedures to be put in place to allow for safe operations regardless of visibility, traffic density, and aerodrome layout
- Conflict prediction and/or detection, analysis, and resolution should be provided
- All users should be provided with the same level of service while operating on the aerodrome surface

A standardized aerodrome mapping database, available to all aerodrome users, would allow implementation of many of these recommendations as is described below.

The A-SMGCS (Doc 9830) forecasts that the projected growth in flight operations will lead to increased surface congestion and system delay unless new techniques (i.e., technologies) are available to ATC to reduce workload. In addition, apron controllers and flight dispatch services will require greater sharing of information to manage the availability of stands and parking areas. Finally, for pilots, supplemental guidance information will be required, particularly under low visibility conditions, to avoid increasing workload as the traffic volume grows.

RTCA has published DO-247 “The Role of GNSS in Supporting Aerodrome Surface Operations³.” Although this document is intended to further develop the performance standards applicable to GNSS equipment for use on the aerodrome surface, it also suggests that GNSS-derived information (i.e., position, velocity, and time) combined with a suitable aerodrome database and these can be used to provide pilots and vehicle drivers with situational awareness and electronic guidance.

Further, RTCA Special Committee 186 has drafted “Operational Concepts, Procedures, and Information Requirements for the Cockpit Display of Traffic Information (CDTI) Applications⁴.” One of the applications included is “aerodrome surface CDTI to improve pilot situational awareness.” This application requires an aerodrome mapping database, for the overlay of surveillance data, to achieve maximum benefits.

A.2.1.2 Overview of Aerodrome Surface Operations

Traditionally, pilots have relied on visual aids such as aerodrome markings (e.g., painted centerlines), signs, and lighting, in conjunction with a paper chart of the aerodrome to navigate from point to point on the aerodrome surface. Radio communication with air traffic control (ATC) is used by pilots to obtain the route to follow while on the surface. As a rule, a “ground” controller will issue route instructions to pilots using explicit instructions and a strict protocol (i.e., phraseology) so that there is no misunderstanding of voice communications exchanged over the radio channel. The pilot must then memorize this route (or write it down), re-state it to the controller for confirmation, and then follow the signs and markings to the destination while avoiding other surface traffic and obstacles. Meanwhile, the ground controller must

• ³ “The Role of GNSS in Supporting Aerodrome Surface Operations,” DO-247, RTCA, January, 1999.

• ⁴ “Operations Concepts, Procedures, and Information Requirements for CDTI Applications,” Draft, RTCA SC-186, Working Group 1, June, 1998.

remember the routes given to all aircraft, as well as all aircraft locations, so that no one is directed into a potential collision. If there is a potential for collision, hold in position and/or hold-short instructions can be issued over the radio frequency to further constrain aircraft movements.

Surveillance on the aerodrome surface is performed by the flight crews based primarily on the “see and be seen” principle to maintain safe separation. Similarly, ATC performs the surveillance task based primarily on visual cues. Occasionally, both pilots and controllers will use radio communications to confirm positions of relevant traffic (e.g., “Delta 635, say your position”). While the alerting and collision avoidance systems provide traffic advisories to flight crews in flight, it is not intended for use on the aerodrome surface. The Aerodrome Surface Detection Equipment (ASDE-3) radar is used in the U. S. to provide secondary surveillance data to the ATC tower; however, it is currently only scheduled to be deployed at thirty-four US aerodromes. ASDE-X, a follow-on aerodrome surveillance system, is intended for deployment at an additional twenty-five non-controlled aerodromes.

These traditional procedures have worked well as aerodrome surface has not been congested and visibility was usually good. However, as traffic volume has increased, the surface is becoming more and more congested, even in clear weather, and there is a need to perform more operations in low visibility and at night to meet an ever increasing demand leading to increasingly complex, large aerodrome layouts.

In order to support flight operations at aerodromes, several other activities are required, each of which are performed by separate organizations or facilities. These include:

- (1) Aerodrome operations: The aerodrome authority is responsible for construction and maintenance of aerodrome resources such as buildings, pavement, lighting, markings, and landing systems (e.g., ILS). They are also responsible for providing emergency response teams such as fire/rescue and aerodrome security in some cases.
- (2) Commercial/Cargo airline operations: These include a wide variety of activities such as apron control, aircraft maintenance/fuelling, baggage/cargo handling, catering services, crew and aircraft scheduling, flight planning, ticketing and training activities such as flight simulations to maintain pilot currency and proficiency.
- (3) General Aviation (GA) and Business Aviation operations: In the US, these operations are typically supported by Fixed Base Operators (FBOs). FBOs support GA and business aviation operations by providing maintenance, fuelling, flight planning, and local ground transportation services. FBOs are typically located away from the commercial concourse/stand areas while still having access to active taxiways and runways.

These three general classes of aerodrome activities, in conjunction with pilot and ATC activities, represent aerodrome surface operations at the larger aerodrome facilities. At smaller aerodrome facilities, only a subset of these activities is necessary to support surface operations.

A.2.2 Navigation Applications that use Aerodrome Mapping Data

Based on the availability of a standardized aerodrome mapping data set, a wide variety of applications can be envisioned. Twelve are described below and are listed and separated by user class. Note that several of the applications can be used by multiple user classes.

Pilots

Chart information

Surveillance and conflict/runway incursion detection/alerting

Route/hold-short portrayal and deviation detection/alerting

Portrayal of digital ATIS information
Aerodrome surface guidance/navigation
Runway operations
Notices to Airmen (NOTAMs) and Aeronautical Data Overlays
Synthetic vision

Air Traffic Controllers

Airline, Cargo, GA, and Business Aviation Operations

Resource management
Training and High Fidelity Simulation

Vehicle Operators

Aerodrome Operations

Aerodrome facility management
Emergency and security service management
Aerodrome Asset Management

A.2.3 Charting Information

Operational Concept

For pilots, a graphical portrayal of the aerodrome site, including aerodrome movement/non-movement areas, is essential to safe and efficient navigation. Currently, this graphical portrayal is provided to flight crews by way of paper charts. An alternate or supplemental means, of graphically depicting aerodromes is by way of a flight deck electronic display. This would provide a tool for pilots to visualize their physical environment while on the aerodrome surface, or while planning an arrival to a specific aerodrome. This tool could also provide access to aerodrome-specific data that are also included in paper charts such as frequencies, operational constraints, and local procedures. In addition, such a display system could make use of a spatial database that included themes, or layers, that would allow pilots to assimilate specific displayed information types with the out-the-window scenes. These themes can include:

Runways	Taxiways	Aprons
Shoulders	Service Roads	Stands
Hold Lines/Points	Paint Features	Jetways
Pavement Segments	Centerlines	Contour Lines
Hydrography	Building/Structures	Fences
Radar Sites	Elevation Models	Signage
Lighting	SMGCS Plans	Obstacles
Navigation Points	Survey Control Points	Concourses
Highways	Primary Roads	Secondary Roads
Land Use	De-Icing Pads	Land Fills

The above table presents a list of terrestrial physical features that can be surveyed and stored in a database. The database may also support multiple spatial models, or polygonal zones. Polygonal zones are 2-D and/or 3-D shapes used to provide spatial cueing or visualization of data by way of illustration. A list of themes that support various modeling constructs is presented in the following table:

Noise Contours	Incursion Zones	Movement Areas
Airspace Cylinders	Ground Water Models	De-Ice Solvent Plumes
Bird Strike Areas	ILS Hold Segments	Tower Field of View
Emergency Response Time/Distance Zones	Approach/Departure Corridors	Obstacle buffer zones

This application of aerodrome databases does not require any interfaces to real-time data and could operate on a “stand-alone” basis in the flight deck.

Benefits

In addition to the graphical portrayal of the aerodrome layout, spatial and tabular information included in the database could be utilized as a source of Aerodrome/Facility Directory data, NOTAM data, communications frequencies, procedures, and other textual annotation information overlaid on graphics/maps that have customarily been included in the charts/manuals. Information could be made available in electronic format eliminating the need for paper copies of maps and charts in most instances. For pilots, this would reduce cockpit clutter and workload during surface operations and ease flight planning activities. This electronic charting information may also be used by other aerodrome users to support:

- Aerodrome operations and facilities management
- Planning, e.g., environmental, noise, construction, etc.
- Leases, pavement utilization, utilities, snow removal, etc.
- Airline/Cargo/GA resource management
- ATC and apron control, routing, dispatch, and decision support tools
- Efficient routing of aircraft and vehicles; conflict detection and alerting
- Emergency response and security operations

Finally, an electronic data-driven chart, distributed to the pilot/user community on electronic media and/or via network (or the world-wide web) connectivity, can be maintained and disseminated in an efficient and cost-effective manner.

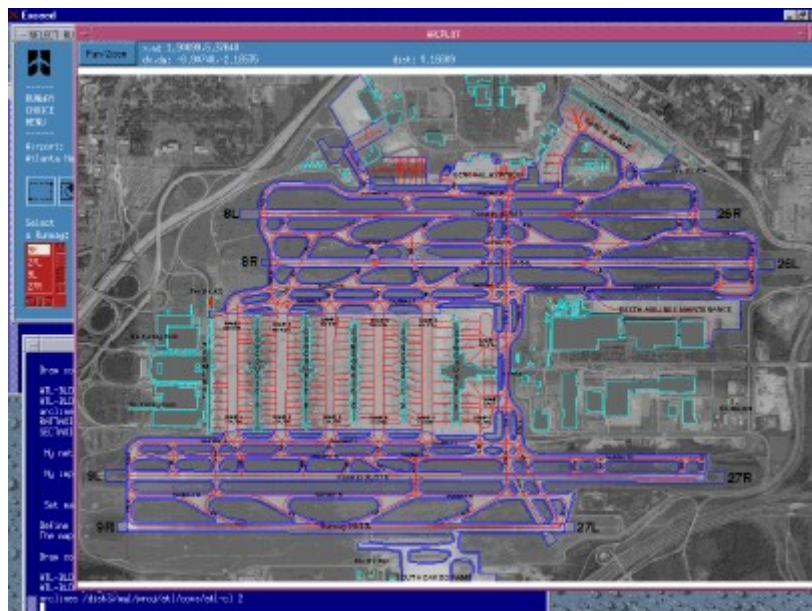


Figure A-2. GIS portrayal of Atlanta International Airport (ATL)

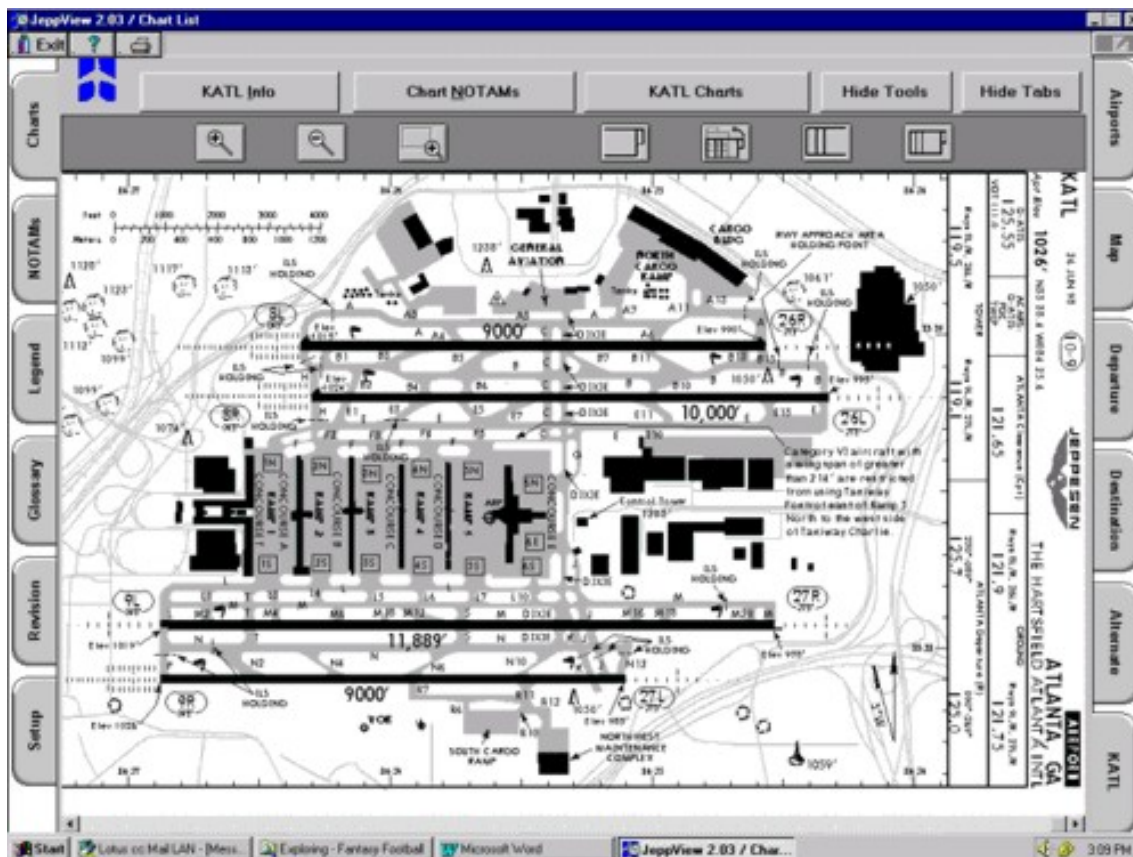
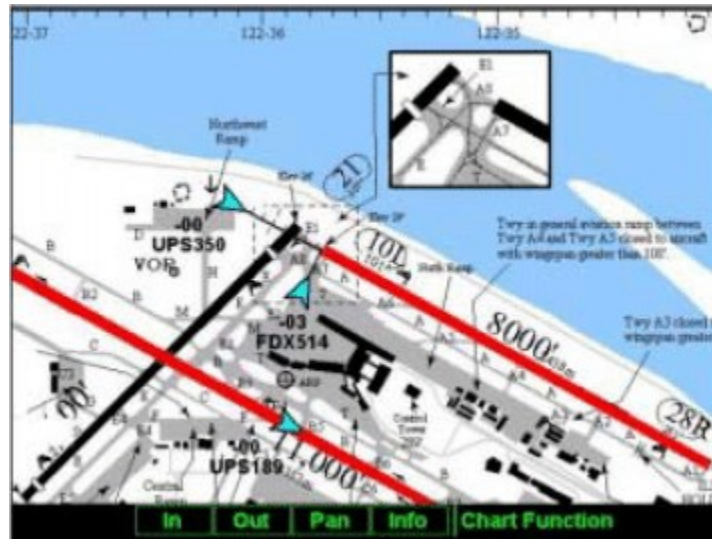


Figure A-3. Example of aerodrome mapping information display



Runway incursions and potential surface collisions can be detected and presented in the cockpit using a graphical portrayal of the aerodrome once surveillance data and an aerodrome mapping database are available. Once detected, alerts can be issued to either ATC (via data link) or directly to the flight crew. This detection and alerting can be functionally similar to the approach taken by AMASS and/or TCAS. This runway incursion alerting concept has undergone flight simulation testing at NASA and flight testing at the Dallas-Ft. Worth International Aerodrome⁹.

⁹ Young, S., and Jones, D., "Runway Incursion Prevention Using an A-SMGCS," Proceedings of the 19th Digital Avionics Systems Conference, October 7-13, 2000.



Figure A-6. Perspective Map Display with Traffic and Route Information



Figure A-7. Plan-View Map Display



Figure A-8. Map display with runway incursion alerting on final approach



Figure A-9. Ego-centric display Showing 3-D aircraft silhouette portrayals

Benefits

For pilots, access to a Cockpit Display of Traffic Information (CDTI) during surface operations at controlled and uncontrolled aerodromes can increase traffic awareness while decreasing the uncertainties associated with available visual cues and radio communications¹⁰. This increased awareness can:

¹⁰ Young, S., and Andre, A., "Cockpit Display of Traffic Information (CDTI) for Improved Aerodrome Surface Situational Awareness", submission to RTCA SC-186, Working Group 3, for inclusion in the Minimum Operational Performance Standards (MOPS) for CDTI, March, 1998.

- Reduce the likelihood of runway incursions and surface accidents
- Reduce the likelihood of navigation errors on the surface
- Enable tighter separations on the surface and higher taxi speeds
- Enable strategic planning to avoid departure queues
- Enable strategic planning by choosing an optimum runway exit
- Reduce the amount of radio communications required

Further, in extremely low visibility conditions (e.g., Category IIIB and IIIC), surface CDTI can become an enabling technology. Despite the fact that autoland and Head-Up-Display (HUD) systems allow Category IIIB landings, these operations are not permitted at VMC flow rates, in large part, because flight crews cannot safely perform “see-and-avoid” while moving on the aerodrome surface. A surface CDTI capability would be critical in enabling higher capacity IMC flow rates on the aerodrome surface.

It should also be noted that, frequently, ATC surface guidance is provided to flight crews relative to other surface vehicles. For example, “Delta 625, follow company traffic” or “American 833, follow the 737 to your left.” A surface CDTI capability would support adherence to these types of instructions in limited visibility as well as reduce uncertainties that may occur when these types of instructions are issued in VMC.

Airline, cargo, GA, and business aviation operations centers could also benefit from real-time surveillance data depicted on a graphical aerodrome mapping database. This capability would enable operations that are more efficient. For example, apron controllers can make more informed decisions about controlling the movement of aircraft and vehicles in the apron areas to avoid conflicts and to reduce delays. In addition, scheduling and managing service vehicle operations (e.g., fuel, baggage, etc.) can be improved by tracking the location of vehicle and aircraft locations.

As with pilots, the primary benefit to vehicle operators of a display of traffic information superimposed onto an aerodrome mapping information is to reduce the likelihood of runway incursions or surface accidents. Low-cost prototype systems have been tested on vehicle platforms (e.g., emergency vehicles) that have shown the potential for this application¹¹. Fire and rescue vehicles in particular can benefit significantly from this technology. This application would allow them to accurately discern the location of accidents and choose the fastest route to the scene avoiding other surface traffic.

A.2.5 Route and Hold-Short Portrayal and Deviation Detection and Alerting

Operational Concept

In today’s aerodrome environment, both departure and arrival taxi routes are provided by ATC to the flight deck by way of VHF voice radio communication. All taxi route instructions are “read-back” by the responsible flight deck crew member to ATC as a way of confirming the instruction. Similarly, hold-short instructions may be issued by ATC to constrain aircraft movements to avoid surface collisions, runway incursions, or interference of ILS protective zone. In the flight deck, taxi routes are memorized (and sometimes written down). Subsequently, the pilots follow relevant signage to reach the destination stand or runway. For arrivals, taxi routes are typically requested by the flight deck after clearing the arrival runway. For departures, taxi routes are typically requested just prior to entering the movement area (on departure from the ramp/apron).

For this type of application, taxi routes would be depicted on a graphical display of the aerodrome layout. There are several ways in which this route could be represented (Figure A-10 and Figure A-11 refer). Figure A-10 depicts the taxi route as a magenta line similar to the way in which it is done on navigation

¹¹ Teeter, R., et. al., “Voice Activated Poor-Visibility Emergency Response System (VAPERS)”, Orbital Technologies, U. S. Air Force Contractor Report, Tyndall Air Force Base, February, 1995.

at the same time enabling an increase in taxi speed¹². This is primarily because uncertainties associated with both the visual aids (i.e., signage) and radio communications are significantly reduced. Another contributing factor to this benefit is that the graphic portrayal of taxi route and hold-short locations is a more natural representation than a series of alpha-numeric symbols that are either memorized or written down.

Depending on the implementation of this application, other operational benefits are achievable. If taxi route and hold-short locations are data linked to the flight deck via Controller-Pilot Data Link Communication (CPDLC), the probability of miscommunication and/or misunderstanding over the voice channel can be reduced. The CPDLC instructions would serve as a reinforcement for voice communications. This would also reduce the amount of voice traffic on the radio channel as the number of “say agains” and progressive taxi instructions to pilots unfamiliar with the aerodrome would be reduced. On the other hand, if taxi routes were entered in the flight deck (or chosen from a menu of standard routes) by the crew after receipt via radio, the operational benefits would still be achievable; as well as removing the workload of “writing” and/or memorizing taxi routes and/or hold-short locations.

Finally, by knowing the assigned taxi route, hold-short locations, and one’s own position, it becomes possible to monitor route conformance during the surface operation. Deviations from route, or moving beyond a hold point, can be detected and alerts can be sent to the crew, ATC, or even other aircraft that may be impacted. Advisories can be generated that would return the aircraft to its route in a direct safe manner.

A.2.6 Portrayal of Digital ATIS Information

Operational Concept

Listed below is a typical message received in the flight deck via the Automatic Terminal Information Service (ATIS). ATIS messages are either pre-recorded and replayed over a radio frequency, or encoded and transmitted digitally to equipped aircraft (D-ATIS).

ORD ATIS INFO G 1556Z. 18011KT 10SM OVC200
29/21 A2986. ARR EXP VECTORS ILS RWY 14R
APCH. ILS RWY 22R ARCH. LAND AND HOLD SHORT
OPERATIONS ARE IN EFFECT. RWY 14R ARR PLAN
TO H/S OF RWY 27L, 9 THSD 8 HND FT AVBL. DEPS
EXP RWYS 22L, 27L. NOTAMS... RWY 18, 36
CLSD, RWY 14L, 32R CLSD. TWY M CLSD BTN TW M4
AND TW M6; TWY P CLSD BTN RWY 4L AND TWY P1;
TWY V2 CLSD; TWY U CLSD; TWY M5 CLSD. PILOTS USE
CTN FOR BIRD ACTIVITY IN THE VICINITY OF THE
ARPT. WHEN READY TO TAXI CONTACT GND METERING ON
FREQ 121.67. ...ADVS YOU HAVE INFO G.

The information “Golf” above for Chicago’s O’Hare International Aerodrome (KORD) at 15:56 will improve the situational awareness in the flight deck once the message has been read, translated, and assimilated. Much of this information could also be presented to the crew as a graphical display overlay that utilizes an aerodrome mapping database and an interface to the digital ATIS receiver. Features of this graphical display could be specifically tailored to ATIS-type messages that are related to geographic information, for example:

¹² McCann, R., et. al., “An Evaluation of Taxiway Navigation and Situation Awareness (T-NASA) System in High-Fidelity Simulation,” Proceedings of the AIAA/SAE World Aviation Congress, September, 1998.

- Active arrival and departure runways outlined or shaded uniquely
- Active “land and hold short” locations depicted
- Closed runway or taxiway segments can be uniquely depicted
- Areas of potential bird strikes can be uniquely depicted

Benefits

The display described above would primarily benefit flight crews by improving situational awareness with respect to the current aerodrome configuration, conditions, and recent NOTAMs. This approach would also reduce the likelihood of misreading the ATIS text or misunderstanding the recorded ATIS issued over the radio. Finally, if the system is designed to automatically receive and display the ATIS information, the crew would be aware of the most recent ATIS update.

It should be noted that a similar display resource could also benefit ATC (e.g., a graphical user interface could be used to generate ATIS information) and the operations facilities (e.g., a tool to aid in flight planning/scheduling as well as aircraft/vehicle servicing).

A.2.7 Aerodrome Surface Guidance and Navigation

Operational Concept

One of the several anticipated applications of GNSS is aircraft navigation on the aerodrome surface. With the advent of GNSS augmentation systems¹³, technology will soon be available to enable aircraft to obtain accurate position information while operating on the aerodrome surface. Standards are developed or under development in this area. Further, proposed Required Navigation Performance (RNP) requirements have been developed by NASA for surface movement¹⁴. Despite the capability of technology (i.e., GNSS) to perform the navigation function (i.e., determining position and velocity), there must be means by which this position is relayed to the flight crew so that they can safely steer the aircraft from the current position to the desired destination. One approach is by presenting current position to the pilot relative to geographic locations stored in an aerodrome mapping database (see Figure A-5 through Figure A-13). These geographic references can be centerlines, guidance lines, runway/taxiway edges, painted markings, and/or obstacles. Using GNSS, an accurate database, and a display, the flight crew can determine, in real-time, both lateral and longitudinal track deviations (independent of visual aids).

In Figure A-5 through Figure A-13, the result of the navigation function is presented to the flight crew with respect to a virtual portrayal of the runway/taxiway centerlines and/or edges. This approach is sometimes referred to as a form of *Synthetic Vision*. Figure A-5 through Figure A-11 and Figure A-13 use a head-down display device, while Figure A-12 uses a head-up display (HUD) device. The centerline and/or edge locations are stored in an aerodrome mapping database. These display concepts are the result of flight simulation and flight test research activities that have demonstrated an approach to low visibility aerodrome surface guidance/navigation using GNSS and an aerodrome mapping database^{6, 9, 12}.

In most visibility conditions, surface navigation display functions, like the ones mentioned above, would be intended to supplement visual cues. Visual aids such as aerodrome signs, painted markings, and lights would continue to be used as the primary method of guidance/navigation. This supplemental information would be used by the crew as needed to reduce any uncertainties associated with guidance presented by the visual aids (e.g., indeterminate sign direction arrows, missing centerline paint, etc.).

¹³ Braff, R., “Description of the FAA’s Local Area Augmentation System (LAAS)”, Journal of the Institute of Navigation, Vol. 44, No. 4, pp. 411-423, Winter, 1997-1998.

¹⁴ Cassell, R., Smith, A., and Hicok, D., “Development of Aerodrome Surface Required Navigation Performance (RNP)”, NASA Contractor Report (CR-1999-209109), June, 1999.



Figure A-12. Aerodrome surface guidance/navigation using HUD

In extremely low visibility conditions or at aerodromes not equipped with sufficient visual aids, surface navigation displays (like the ones pictured) may be the primary, or sole, means of guidance/navigation. Currently, for either of these cases, aerodrome operations cease; as there is no means of safe surface navigation.



Figure A-13. Head-down guidance/navigation display

Benefits

For pilots and vehicle operators, portrayal of current position on a display (like the ones shown in Figure A-5 through Figure A-13), can result in operational benefits, particularly if current aircraft position is depicted graphically relative to geographic data. This function provides benefits similar to those provided by Navigation Displays (NDs) that are currently being used in the flight regimes. Access to this display during the surface operation (and prior to landing) can increase spatial awareness while decreasing uncertainties associated with available visual aids. This increased awareness can

- reduce the likelihood of runway incursions and surface accidents
- reduce the likelihood of navigation errors on the surface
- enable higher roll-out, turn-off, and taxi speeds
- reduce the amount of radio communications required

Further, as weather conditions deteriorate, these benefits become more pronounced. In extremely low visibility conditions, this guidance/navigation tool can become an enabling technology. Despite the fact

that autoland and HUD systems allow Category IIIB landings, these operations are not permitted at VMC flow rates, in large part, because flight crews cannot safely navigate while moving on the aerodrome surface. A surface navigation function that supplements visual aids would be essential in enabling “0/0” flight operations as well as higher capacity IMC flow rates on the aerodrome surface.

A.2.8 Resource Management

Operational Concept

Commercial airlines, cargo airlines, and services who manage GA and business aviation operations, are responsible for many resources on and about the aerodrome vicinity. Examples of these resources include:

- Aircraft
- Service vehicles
- Maintenance hangars
- Simulation facilities
- Apron control operations facilities
- Operations control centers

An accurate, complete, aerodrome geographic information system (GIS) database and associated toolset can be made available to aerodrome operations control centres, apron control operations facilities, and maintenance facilities to improve operational efficiency. Further, efficiency models can be developed, using ad hoc analysis or real-time methods, that maximize procedural efficiencies associated with crew bus dispatch, aircraft/vehicle routing, and asset management.

A graphical portrayal of aerodrome surface features, obstacles, and/or movement boundaries along with information on resource status/location can be combined in a GIS layered database that can be accessed by appropriate personnel. Networked terminals providing access to this database can be located based on the needs of a specific airline/services. In addition to aerodrome mapping information, this database can include the following types of information layers relevant to resource management:

- (1) Service facility information
- (2) General and business aviation maintenance areas
- (3) Asset identification, status, and inventory
- (4) Cargo maintenance areas
- (5) Parking/stand assignments and status
- (6) Airline maintenance
- (7) Apron route planning
- (8) Crew scheduling and dispatch information

An example is the Surface Movement System (SMS) that integrates airline schedules, stand information, flight plans, radar feeds, and runway configuration (departure splits and landing direction) to improve coordination and planning of the ground aerodrome traffic operation. The integrated information is then re-transmitted over the networked system and shared between the Air Traffic Control Supervisors, Aerodrome Managers/Operators, Air Traffic Controllers, Airline Operators, and Apron Operators at the aerodrome. For aerodrome mapping databases (AMDBs) to be of use to SMS, the following data elements are required: apron centerlines, apron edges, stand centerlines, stand locations, aircraft that a

particular stand can handle, and stands associated with a particular apron. Accurate standardized AMDBs would allow SMS to be more easily configured, ported, and customized to any given aerodrome surface environment.

Benefits

A spatial aerodrome surface database and an associated toolset can support varied needs of commercial/cargo/general aviation/business aviation operators. It addresses the need for a component-based system that can enable more efficient monitoring and movement of resources. These resources include: aircraft, service vehicles, equipment, and crew. Valuable commodities can also be more efficiently managed including passengers, baggage, and cargo. Tracking and identification of physical resources can also be managed using a GIS system and its associated database.

A.2.9 Training and High Fidelity Simulation

Operational Concept

Flight simulators are used in all phases of advanced flight training/education; including pilot type ratings and regularly scheduled mission rehearsals. Flight simulators are classified into four different quality levels (JAR-STD 1A): A, B, C, and D. All levels require a database (JAR-STD 1A, AMC STD1A.030 paragraph 2.3) that includes:

- General aerodrome outline
- All runways
- Glide slope transmitter position for all runways
- Position of the glide slope receivers for all runway
- Type of approach lighting system for all runways

In addition, level D certified visual systems (JAR-STD 1A, AMC STD1A.030 paragraph 2.3) require sufficient scene content to recognize:

- Aerodrome features
- Terrain with major terrain features
- Major landmarks around the aerodrome

Far beyond these requirements, state-of-the-art flight simulator databases also have:

- Taxiway outlines
- Taxiway markings
- Taxiway signs
- Apron markings
- Parking positions
- Aerodrome buildings
- Gates and jetways

Current training simulation systems only provide relative positions. With the introduction of new procedures such as GNSS approaches, all simulation aerodrome databases will need to be geo-referenced to precise absolute three-dimensional positions. WGS-84 geo-referencing is required to be GNSS compliant. The simulator integration of Ground Proximity Warning Systems (GPWS) requires terrain and obstacle information in the vicinity of an aerodrome. For simulation purposes, precise aerodrome data is needed after integrating next-generation navigation displays with moving map taxi-guidance functionality.

For realistic training, all geo-spatial information stored within each individual aircraft system (e.g., GPWS, flight management system, navigation display, etc.) will have to match the database stored in the simulator's visual database. The only common reference system that these distinct systems share is an geocentric positioning system, i.e. the World Geodetic System – 1984 (WGS-84).

Benefits

All simulator database vendors can use geo-referenced aerodrome databases as the basis for future simulator visual databases. Currently, they replace all available databases to make them compliant with WGS-84-referenced GNSS approach procedure requirements. Cost can be significantly reduced by the availability of aerodrome databases. Even current geo-referenced databases used in simulators can be enriched with additional more precise geo-information.

Problems with an insufficient matching of moving map guidance displays and algorithms such as those employed by GPWS can be avoided if the databases used to generate visual scenes in simulators are consistent with (if not identical) to those used onboard aircraft.

A.2.10 Aerodrome Facility Management

Operational Concept

There are six primary categories of activities that come within the scope of aerodrome facility management:

- Planning
- Aerodrome design
- Facility design
- Construction
- Environmental
- Administration

Each of these activities can benefit from the availability of aerodrome mapping information. To ensure consistency across the applications, a GIS layered database structure with attribute data can be utilized. Every aerodrome implementation will be unique. It is anticipated that the primary repository for this database will be some form of an aerodrome operational control center. Secondary repositories, with full functionality, may be located at maintenance control centers, aerodrome engineering centers, and aerodrome movement area control centers.

The current problem at most aerodromes is the establishment of “data islands” within each organization established within one aerodrome. Consequently, the practice has been to develop databases for a specific need. The result has been duplicated databases with inconsistent key fields and an environment where no standards exist. Many aerodrome departments use incompatible vendor-specific formats that lead to inefficiencies and low performance, as well as high costs and low quality. Storing data in a GIS database structure can result in tremendous efficiencies being realized.

A.2.10.1 Planning

Capacity, land use, noise, and environmental management are issues facing the aviation industry and aerodromes in particular. The planning process is integral to developing and maintaining aerodromes and resolving issues relating to technical and legislative changes that affect the individual aerodrome, and aviation industry as a whole. Planning databases may contain layered information that would be resident in an enterprise database.

A.2.10.2 Aerodrome Design

Bigger, heavier aircraft and increased operations are producing a strain on aerodromes worldwide. Aerodromes are quickly approaching capacity, while runway, taxiway, and apron availability is becoming severely limited. Pavement at many aerodromes is far beyond its useful life and in some instances, is failing. In addition, recent changes to aerodrome signage requirements have resulted in a need to install new signs at aerodromes. Aerodrome design database information must account for present and future needs. In order to meet these requirements, the data must be retrievable in such a way that it can be used by consultants, planners, and designers to develop three-dimensional simulations of one aerodrome. These simulations will allow multiple alternative schemes to be assessed before any one scheme is adopted.

A.2.10.3 Facility Design

Roadways, buildings, mechanical, electrical, and plumbing systems are special issues that arise when facilities are located on aerodromes. Facility design database information should include the requirements for safety, airspace restrictions, operational issues, noise abatement issues, environmental issues, and revenue-generation issues such as terminal space leasing to tenants.

A.2.10.4 Construction

Construction personnel, managers, and inspectors require specific information when operating in an aerodrome environment. Databases are required to understand individual aerodrome operations, government regulations, aerodrome safety requirements for construction, and coordination of construction activities.

Construction management services on aerodrome projects may require information on special phasing considerations to prevent operational interruptions. To reduce administrative burdens and related costs incurred by aerodromes and aerodrome planning boards, cooperation between planner, designer, contractor, construction manager, and the aerodrome administration are critical for both large and small projects.

A.2.10.5 Environmental

Virtually every aerodrome project has a critical need to identify and define environmental issues and solutions that provide for a realistic design and implementation plan. Issues of concern to aerodrome operators include performing environmental evaluations of facilities, providing training for personnel, administering environmental programs, and developing environmental manuals.

A.2.10.6 Administrative

Aerodrome planning boards have requirements for familiarity with the policies, procedures, and internal structures of each aerodrome, and the sources that fund work to be performed at each aerodrome. To that end, each aerodrome must maintain close relationships with the national civil aviation authority, and must have a thorough understanding of any plan to develop and expand aerodromes. The information maintained in databases assists the aerodrome staff in preparing development strategies for aerodrome improvements.

Benefits

The benefits for aerodrome facility management are categorized as:

- Reduced staff time for analysis
- Quick response to questions
- Ability to address complex issues
- Ability to provide better information to the decision makers
- Reduced cost to develop applications
- Creation of a basic framework to administer geospatial data

The use of consistent, standardized data results in the creation of an efficient data warehouse for the aerodrome organization. The data warehouse concept results in beneficial data management and analysis technology and techniques. The data are used to enhance the value of the aerodrome's data by replication, and it becomes more than just data, it becomes a set of tools. The initial creation of a data warehouse requires a commitment of resources. However, the payback to the aerodrome organization can be realized in multiple efficiencies.

Another benefit of such a database is the capability of data to retain its natural spatial information. For example, data can be visualized as in the real world and thus, can create a common language for the aerodrome organization to use. In addition, spatial queries will serve to broaden the information that is available, and users will want to use the system because it is user-friendly and intuitive.

Some of the benefits of standard data are:

- Ease of processing and integrating data into various applications
- Longevity given to the data
- Assistance given in maintaining links to the legacy systems
- Ensured compatibility between systems
- Cooperation facilitated between database application developers
- Opening to additional external sources of data

A.2.11 Emergency and Security Services Management

Operational Concept

A critical need exists to integrate the system designs of the adverse weather navigation systems being developed for aerodromes. Systems are being developed for both aircraft and aerodrome ground vehicles (e.g., emergency and security vehicles). The problems and requirements related to central control and safe operation during simultaneous surface movement of a mixed vehicle fleet are broad in scope. Challenges exist under normal and emergency conditions that require all vehicles be controlled, monitored, and managed by a central control function. All aerodrome surface vehicles (i.e., aircraft and vehicles) must use common guidance reference data having a specific accuracy to prevent potential problems that would be associated with uncoordinated activities during adverse weather conditions. It becomes essential that cost-effective and dependable methods and designs be developed that will ensure safe operation of a mixed fleet consisting of aircraft and ground vehicles when operated simultaneously during adverse weather conditions.

Driven by the need to respond quickly to accidents or security breeches occurring in poor visibility conditions, ground vehicles can be outfitted with equipment to improve response capabilities. The capabilities provided can enable aerodrome Rescue and Fire Fighting (RFF) operation centers and the fire fighters themselves to more quickly locate a fire/crash sight during the times of adverse visibility (i.e., at night and/or during poor weather conditions). Security operations centers and the associated personnel and vehicles have similar needs when responding to a site where there is a potential security threat.

Using a Primary Base Station (PBS) located in an aerodrome Operations Communications Center (OCC), coordination and management of emergency and security services can be performed. These services include:

- Tracking vehicle location and identity
- Maintaining/distributing checklists and procedures
- Monitoring vehicle status
- Acquiring aircraft data
- Acquiring incident status data
- Acquiring hazardous material information
- Enabling/disabling alarm functions
- Dispatching emergency/security resource

The PBS display can be supported by a GIS map database of the aerodrome and surrounding area to include the Aerodrome Emergency Plan (AEP) area; typically a nine kilometers radius from the end of each runway. Further, the map database can be layered with the option of displaying any combination of informational layers available to either the control center or the vehicle.

Benefits

Emergency and security vehicles outfitted with equipment and aerodrome surface databases as described above will be able to respond even faster and with more situational awareness particularly in poor visibility conditions. OCCs will be able to work more efficiently to control and monitor movements to ensure conflict avoidance and rapid response. The use of common guidance information, having a high degree of integrity, can prevent potential problems that would be associated with uncoordinated activities during adverse weather conditions. Development of aerodrome surface databases used to support simultaneous surface movement of mixed vehicle and aircraft fleets can increase safety margins and performance. Emergency and security operators using aerodrome databases and associated displays (Figure A-14) can also:

- Reduce operator workload
- Increase coordination/dispatch capabilities
- Enable clear, unambiguous communication of information
- Enable drivers to travel the most direct routes to a prescribed destination (e.g., fire location) quickly and safely regardless of visibility

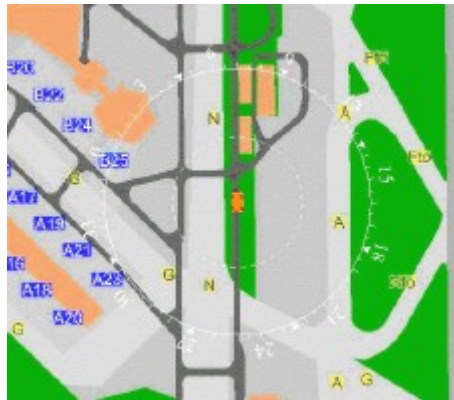


Figure A-14. Emergency/security vehicle display

A.2.12 Runway Operations

Operational Concept

Using a robust position sensor (e.g., augmented GNSS), a display (either auditory or graphical), and an adequate aerodrome database, guidance can be provided in real-time to pilots so that they can effectively

manage aircraft speed and location during take-off and during landing roll-out and turn-off from the runway.

During take-off, access to sufficient runway information can allow a guidance profile to be generated based on conditions that may be changing dynamically. This guidance can be provided on either the personal flight display, navigational display, HUD, or any other available display in the flight deck. Further, important situational information could be provided, such as where on the runway the aircraft is projected to reach specific V speeds and where the flight crew would need to consider a take-off abort. Finally, alerts could be generated to warn the pilot if there is insufficient runway remaining to either perform a take-off abort or to lift-off.

Similarly, during the last stages of landing (e.g., the flare) and during landing roll-out and runway exit, sufficient runway information could enable guidance profiles to be generated to aid the pilot's decision making in these critical stages. This guidance could be tailored to provide several functions:

- Warning if landing fast or long
- Guidance to optimal touchdown point
- Flare guidance
- Optimal guidance to desired exit
- Runway remaining guidance
- Warning of potential overrun
- Deceleration guidance to ensure passenger comfort and reduce brake wear

Finally, in conditions of low visibility or at night, this application could help the pilot ensure that he is maintaining an appropriate track, both laterally and longitudinally, during take-off roll, landing roll-out, and normal taxi. In conditions of good visibility, this is done using visual references such as center lines/lights, runway edge lines/lights, and other relevant runway signs. An aerodrome moving map could be used to prevent runway excursions, whereby the landing gear exits the runway or taxiway, leading to aircraft shutdown, and tow.

A great deal of research has been done involving these applications at various research centers. For example, NASA has developed a Take-off Performance Monitoring System (TOPMS) and a Roll-out Turn-off (ROTO) guidance system. Both of these conceptual systems were designed to provide many of the functionalities described above.

Benefits

Potential benefits of this application for take-offs include:

- Reduced number of take-off aborts
- Reduced likelihood of take-off accidents
- Optimized aircraft performance during departure roll
- Improved fuel efficiency

Potential benefits of this application for approach and landings include:

- Reduced number of overruns
- Reduced number of go-arounds
- Reduced/predictable roll-out times in any visibility or weather condition
- Reduced brake wear
- Optimized aircraft performance
- Fewer runway excursions

A.2.13 Notices to Airmen (NOTAM) and Aeronautical Data Overlays

Operational Concept

Aeronautical data overlays, including aerodrome NOTAM, are kind of advisory information that could be disseminated to flight crews using a Flight Information Services – Broadcast (FIS-B) data link system. FIS-B is an emerging data link concept (with several implementations underway) that is intended to provide weather and other flight advisory information to pilots in a way that will enhance their awareness of the flight situation and enable better strategic decision-making. The information provided through FIS-B is advisory in nature, and is considered non-binding advice and information provided to assist in the safe conduct of a flight. With this information, pilots will be better able to assess potential hazards as well as make better decisions that will improve operational safety and efficiency. At present, when the weather deteriorates, voice radio calls from pilots to air traffic controllers or to flight service station specialists requesting FIS-B kinds of information become more necessary and more frequent. This overloads voice radio frequencies just when the demand for the data is the highest. It is envisioned that FIS digital broadcast data will be continuously received and stored to be readily available as needed or requested by the pilot.

Implementation of an FIS-B data link system is not intended to replace existing voice radio FIS services. Loss or non-receipt of FIS-B data link services would not be considered flight critical. In the initial implementation, it is anticipated that FIS-B data link services will be used primarily to supplement or complement established sources of weather and operational information, including receipt of an integrated aeronautical information package prior to departure. Existing sources such as the Flight Service Station network, ATC facilities, and/or the corporate/airline dispatchers, would still be available to provide timely data. In the end state, FIS-B services will assist both individual pilot and ATM collaborative decision making (CDM) processes.

As envisioned, graphical or other display of NOTAM information can be facilitated by the Aerodrome Mapping Database (AMDB). A comprehensive AMDB will include all the required “raw materials” for portrayal of graphical NOTAM, such as runways, taxiways, and aerodrome structures. The NOTAM and aeronautical data overlay concept is an operational concept as to how graphical NOTAM / aeronautical data could work with the AMDB. In the envisioned application, the graphical display of the data can be described as overlay graphics referenced to and correlated with AMDB objects. For example, a runway closure could be depicted as a graphical overlay of the runway object stored in the AMDB. An example is given below.

Benefits

The anticipated benefits of this concept are as follows:

- Better and more efficiently communicated information
- “One-stop” shopping for information
- Enhanced situational awareness
- Less reliance on today’s dispatch release form
- Less concern that inaccurate, incomplete, or out-dated information was made available
- En-route updates would be updated by FIS data link, and provided as textual and as graphical overlay products
- Near instantaneous dissemination of SUA and aerodrome-related NOTAM and related information
- Reduced communications costs because of use of a public use, not dedicated, land line system
- Less data entry delay because other parties other than the source originator would be eliminated from the process of data entry and verification. The originator would enter time-perishable data directly into the system, with little if any delays

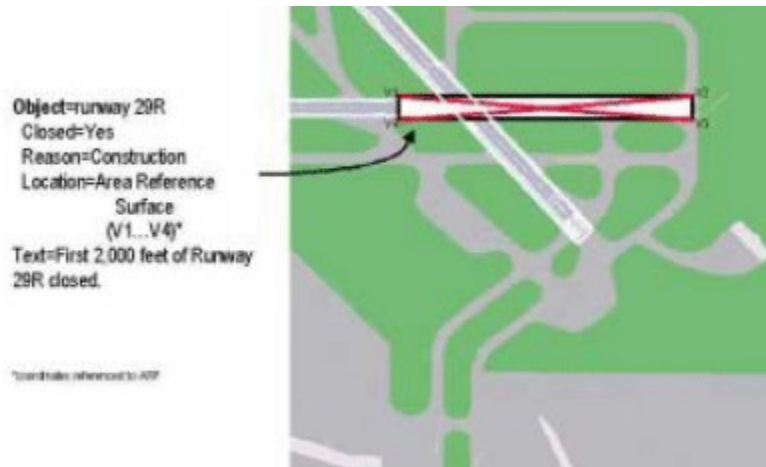


Figure A-15. NOTAM graphical overlay denoting portion of runway closed

List of selected NOTAM that could be graphically displayed using an AMDB

NOTAM	Attribute Specification
Closed runways	<i>Object name (runway), closed, reason, surface referencing polygon</i>
Closed taxiways	<i>Object name (taxiway), closed, reason, surface referencing polygon</i>
Designated construction areas	<i>Object name, reason, surface bounding polygon, hours of construction activity</i>
Temporary grass cutting, snow plowing operations, agricultural activity/areas	<i>Object name, closed, reason, surface referencing polygon, time started, time ended</i>
Clutter/contamination on specified runways and taxiways	<i>Object name, reason, amount, surface bounding polygon</i>
Lighting equipage and status (VASI, PAPI, ALSF-2, etc)	<i>Object name (light), location, status</i>
Signage (e. g., missing, blown-over, obscured, etc)	<i>Object name (signage), location, status</i>
Runway and taxiway markings (e.g., worn, missing, snow covered, etc)	<i>Object name (runway), surface type, surface condition, paint, status, surface referencing polygon</i>
Areas of low-braking effectiveness	<i>Object name(designed area on apron), special comments, referencing polygon</i>
Engine maintenance run-up areas and heading alignments	<i>Object name (designated area on aerodrome), heading alignment required, special comments, referencing polygon</i>
Location of services on aerodrome with available parking highlighted (general aviation parking/refueling areas)	<i>Object name (surface non movement area), special comments, surface referencing polygon</i>
Designated customs clearing parking areas	<i>Object name (designated surface non movement area), special comments (e.g., hours of operation; alternative parking area after hours), surface referencing polygon</i>
Communication frequencies	<i>Object (active aerodrome surface communication frequencies), description, referencing polygon</i>
Gate/apron closures	<i>Object name (gate/apron), closed, reason, surface referencing polygon</i>

A.2.14 Asset Management on the Aerodrome Surface Using Hand-held Computers

Operation Concept

In today's busy aerodrome environment, aircraft frequently arrive at an aerodrome only to find that they must wait for an available gate or, wait for a ramp agent to reposition the ramp-way to the aircraft. Additionally, service vehicles (such as refuelling trucks); often spend extra time searching for parked aircraft, especially at night, often without any mechanical or electronic means to assist them.

At very busy aerodromes, surface movement delays often produce ripple effects that extend well beyond the ramp area and into the aerodrome surface movement. For instance, surface and "push-back" delays directly affect departure timing. Oceanic flight "slot times" at track entry fixes are very sensitive to these delays. Missing a departure slot can easily delay the take-off of a flight for several hours.

Sometimes delays can affect safety. For example, sequencing to de-icing areas, and subsequent "hold-over" times prior to take-off, are all subject to critical timing and scheduling to minimize delay. It is in this operational context that airline, aerodrome staff, and air traffic managers must have a common, shared, situational awareness.

In the following concept of operations, appropriate personnel would be equipped with a small hand-held computer device. Each computer would have a flash card for wireless communication via TCP / IP with a local, Intranet-based, aerodrome information system. Each computer would also have a small database that would contain aerodrome slot information, and would receive on-line flight plan data from ICAO FPL, DEP, DLA, CNL and CNG messages, as well as actual data from departure and arrival movement or ACARS messages. A simple installed software application would convert flight plan information into intuitive graphics. This software would create and position special color-coded icons on the display (see Figure A-16). These portrayals would be displayed in a time-line based manner.

In the portrayal, below, the "beginning" and "end" of the orange shape represent the arrival and departure aerodrome slot times. The dark blue shapes depict the estimated out, off, on, and in times (i.e., off-block, take-off, landing and in-block times) as well as the estimated turn-around times between two flight segments. The green shapes would be resized depending on the actual times while the vertical magenta line would show the current local time. ADS-B and TIS-B data would provide this information, including provision of accurate surface movement predictions. Differences between the assigned aerodrome slots and the planned/actual times would also be graphically depicted. The user could zoom the map, and scroll the picture for better visualization of a specific aircraft or vehicle. The aircraft's identification and current position would be depicted and electronically transferred (by use of ADS-B or other data link) to the aerodrome information system, which would then re-broadcast it.

Each computer would have a GPS flash card, allowing aerodrome management to know where all surface vehicles are, assuming that there is GPS line-of-sight coverage.

A GSM flash card could provide each device with access to the local aerodrome map data base or to other aerodrome information systems. This same concept could include aerodrome refueling, baggage, and servicing vehicles. Graphical ATIS and graphical NOTAM "overlay" information could also be displayed on these small screens to assist ground personnel.

These devices would be equipped with tactile displays. Ramp agents and others could then use these input devices to enter "operational events" (such as the beginning and end of servicing) by simply touching the buttons on the screen with a stylus or finger.



Figure A-16. Hand-held computer using aerodrome mapping data¹⁵

Benefits

This application could reduce surface movement delays, thereby enhancing airline and facility operational efficiency. Collectively, this application would assist airline employees in better synchronizing work tasks with aircraft arrival and departure schedules. Dispatchers and ramp controllers would know the precise location of all aircraft and their status. Gate agents would know exactly when an aircraft would arrive at a stand/gate. Refuelling vehicles, service vehicles, and emergency response vehicles could easily locate a specific aircraft (especially if it was remotely parked).

A.2.15 Synthetic Vision

Operational Concept

An aircraft's ability to conduct flight operations at aerodromes is dependent upon a number of factors. Among them, reduced visibility is a significant factor. As weather and visibility conditions deteriorate, it is increasingly difficult to conduct flight operations in the same manner and at the same rate as in visual meteorological conditions. While today's technology provides solutions to many of the problems caused by low visibility, the potential now exists to provide information well beyond what the pilot is able to see even on a clear day. The operational concept is to create a *virtual visual environment* that all but eliminates reduced visibility as a significant factor in flight operations, and enhancing what the pilot can see even in the best of visibility conditions¹⁶. A virtual visual environment can be described in terms of its components and the operational flight phases it supports.

With respect to aerodrome operations, the synthetic vision "virtual visual environment" is composed of three components: an enhanced intuitive view of the aerodrome environment, conflict detection and display, and precision navigation guidance. The intuitive view is derived from an aerodrome mapping database with multi-system information superimposed or overlaid. This information is comprised of tactical information typically found on a primary flight display as well as strategic information typically found on a navigation display. Since cluttered displays are undesirable, pilots will need the ability to choose certain features so that the system and its displays will be able to present an intuitive and simple-to-comprehend visual portrayal.

• ¹⁵ Photo provided by EUROCONTROL.

¹⁶ Williams, Dan, et al, "Concept of Operations for Commercial and Business Aircraft Synthetic Vision Systems," Version 1.0, January 2001, NASA Langley Research Center.

Many of the applications already listed in this appendix have already been demonstrated in the operational environment using synthetic vision technology including:

- Surveillance and conflict (runway incursion) detection and alerting
- Route and hold-short portrayal and deviation detection and alerting
- Portrayal of digital ATIS information
- Aerodrome surface guidance/navigation
- Runway operations

Please refer to the section of this appendix that describes these applications in a greater detail for sample synthetic vision display.

Benefits

Current technology allow flight crews to perform “all-visibility” en-route flight operations as well as low-visibility approaches and landings to appropriately equipped runways. Synthetic vision systems have the potential to go beyond this present capability, and to extend it to include all-weather surface operations. Such an expanded capability will enhance safety and provide operational benefits. Some synthetic vision systems are expected to emulate day visual flight operations at night and in limited visibility conditions. Others will provide visual cues commensurate with an ego-centered VMC view from the cockpit. Using synthetic vision systems, the overall accident rate and hull loss rate is expected to become that of day visual flight operations. Some of the expected safety benefits with respect to aerodrome operations include: runway incursion risk reduction, improved pilot situational awareness, improved non-normal situation response, and improved compliance with air traffic clearances and instructions. Potential capacity and efficiency benefits have also been identified, including reduced arrival and departure minimums, inclusion of additional multi-runway operations, and greater aerodrome access.

Appendix B: Remote Sensing Technologies

B.1 Summary

The objective of this appendix is to provide basic information to the data integrator regarding remote sensing technologies for the generation of terrain databases. The main aspects outlined deal with:

- » Sensor types,
- » Characteristics of elevation models produced using stereo aerial photography, stereo pairs of satellite imagery, interferometric synthetic aperture radar and lidar,
- » Characteristics of existing and future data acquisition systems.

Note: When using high-altitude reflective sensing, the elevation values provided are a complex product of the sensor resolution area.

B.2 Sensor Types

There are two types of sensors:

1. Passive (or optical) sensors, which capture electromagnetic information that originated at the Sun and is reflected from the Earth's surface. These include aerial photography, scanners, push-broom and CCD array types.
2. Active sensors, which illuminate the scene and capture the reflected information from the ground surface. A typical example is a radar or lidar system.

B.3 Stereo Aerial Photography

Aerial photography is instantaneous imaging of the terrain surface. As such, the electromagnetic rays which give rise to the image have the same attitude and position in space with respect to a co-ordinate reference system. These are the so-called exterior orientation parameters of the aerial photograph. Figure B-1 illustrates the concept. The parameters that define the position and attitude of a body in space are:

- » three coordinates (X, Y, Z) define a position in space.
- » three attitude angles (Φ , Ω , K) define the attitude of the corresponding body (i.e., camera) in space with respect to a 3D co-ordinate reference system.

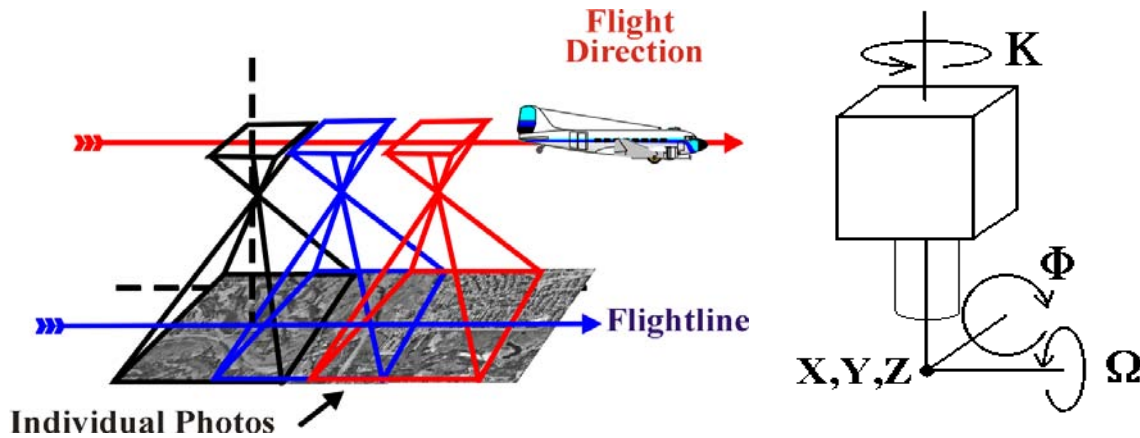


Figure B-1. Concept of stereo aerial photography

Each point of the aerial photograph has the same exterior orientation parameters and is equal to the parameters of the photogrammetric camera at the instant of exposure.

B.4 Stereo Satellite Images

A satellite image can be thought of as an image formed by a successive integration of image lines. An array of light sensitive devices captures the information (i.e., electromagnetic waves) coming from the ground. The captured light is converted to an electrical pulse that is transformed to a digital number and stored for transmission to a ground antenna.

Although a satellite image is exposed line by line in a continuous mode while the platform is moving in its orbit, a set of exterior orientation parameters are valid only for one line at a time.

The main geometrical difference between an aerial photograph and a satellite image lies in the fact that a satellite image does not have constant values for its exterior orientation parameters. They are approximately constant for one line (perpendicular to the instantaneous orbit direction), but vary from line to line. All points of an aerial photograph have the same exterior orientation parameters.

Aspects to be taken into consideration whenever satellite images are used for mapping purposes are the strong effects of Earth curvature and atmospheric refraction. The distortion of the satellite image caused by the Earth's curvature and its variation is more significant than the effect of atmospheric refraction.

B.5 Interferometric Synthetic Aperture Radar (IFSAR)

IFSAR is a technique that uses the relative phase difference between two coherent synthetic aperture radar (SAR) images, obtained by two antennae separated by an across-track baseline, to derive a measurement of the surface height. The baseline length is an important design parameter since the height error diverges as the length approaches zero. Conversely, if the baseline length is too large, the returns from the two antennae become de-correlated, increasing the phase measurement error. A block diagram of the basic process is illustrated in Figure B-2.

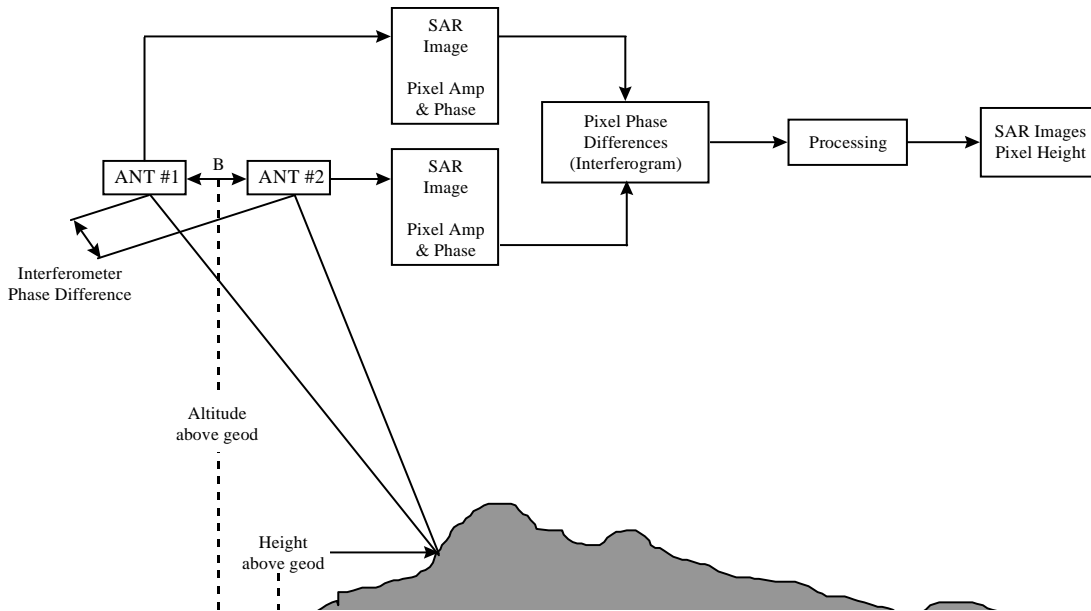


Figure B-2. Concept of operations for IFSAR system

Highly accurate navigation information provided via tightly coupled differential GPS and inertial information drives this process. The first stage of the process is to form the image for each channel. This involves range compression, range curvature correction, and azimuth compression to form a slant plane image. An interferogram is created during the post-processing routine to extract accurate height information from the airborne data. The interferogram is created by combining the two complex SAR image data channels through a process of multiplying one channel by the conjugate of the other on a pixel-by-pixel basis.

To solve for the height, it is critical that the position, attitude, and length of the baseline B are known to the highest possible accuracy. For this reason, the IFSAR antennae baseline must be stable. The swath width is dependent on the height above ground. As the height above ground decreases, so too does the ground coverage. The two critical parameters for the coverage are the far incidence angle and the antenna beam width.

An IFSAR system generates two main product types:

1. **Digital Elevation Models (DEM):** A high resolution IFSAR system produces DEMs (see Figure B-3) with vertical accuracies ranging from 30 cm to 3 m, with post spacing from 5 m, and with horizontal accuracies of 1.25 m and 2.5 m.
2. **Ortho-rectified Image (ORI):** IFSAR high-resolution images (see Figure B-3) are ortho-rectified using the simultaneously generated DEM. Consequently, the radar imagery is presented with all standard radar viewing angle height distortions removed. These images are registered to a desired projection and are mosaicked into image maps. IFSAR digital images can be used to create maps at scales as large as 1:5,000.

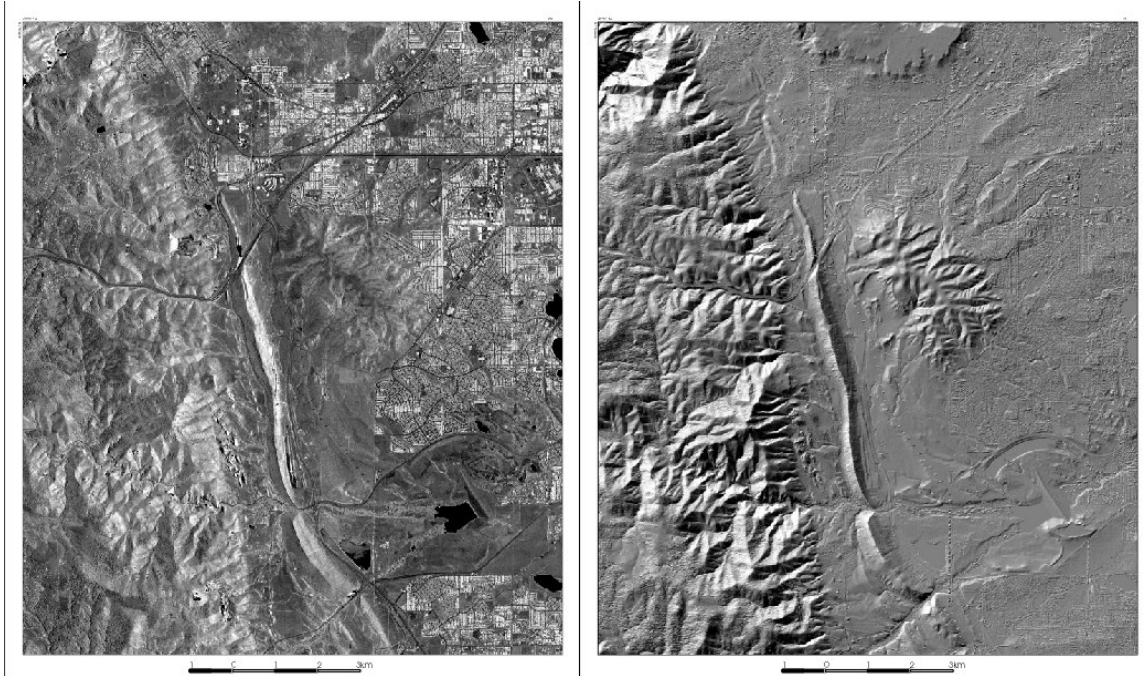


Figure B-3. IFSAR DEM and ORI products

B.6 Light Detection and Ranging

Airborne laser scanning systems, often referred to as LIDARs, are characterized by their transmission of pulses of optical radiation (usually near-IR) on either side of the aircraft nadir such that a zigzag or similar pattern of spots sample the terrain or objects upon it. The side-to-side geometry is usually effected by a rotating mirror or other scanning implementation. The forward motion of the aircraft then adds the second dimension. The back-scattered pulses are received by the LIDAR system, and through time-of-flight measurement, the range or distance to each sample is determined. Sample separation and swath width is determined by the various operating parameters (pulse rate, scan frequency, maximum scan angle, aircraft altitude, velocity, etc). Typical sample spacing may range from 50 cm to 5 m while swath widths are normally several hundred meters. The spot diameter of the samples is usually about 0.1 – 1.0 m diameter, also depending on altitude.

The second key component of an airborne LIDAR system is its combined GPS and Inertial Measurement Unit, which allows the range samples to be converted to (X,Y,Z) coordinates. These samples are usually an irregular set of points that can be subsequently used to create either a regularly gridded DEM or a TIN.

If the reflecting surface is the bare ground, the elevation accuracy may be in the range 15 – 30 cm (RMSE) while the horizontal accuracy of the points is usually 1 – 3 m (RMSE). If the reflecting surface is vegetated, some of the pulses will scatter from the vegetation, while some may penetrate through openings to the ground. The degree of vegetation penetration depends on the vegetation characteristics as well as the LIDAR system operating parameters. These factors will therefore determine how densely sampled and how accurate the resulting bare-earth DEM will be.

B.7 Digital Ortho-Rectified Imagery

This section contains information related to Digital Ortho-Rectified Imagery (DORI). DORI is a part of photogrammetry science and has a significant role in 3D scene visualization when it's used together with digital terrain modelling (DTM), extracted objects, textures, and metadata which can be provided for all

scene layers. DORI is particularly effective when it is draped, or overlaid, onto terrain data for a photorealistic 3D image of the projected scene. The 3D scene visualization tool provides the ability to have links to obtain information about selected objects in the scene and other information such as metadata, change of date and time, and season.

Today DORI is used for revising existing maps, flight simulation software, and it is being used as source data for digitizing map features such as airport layouts. The importance of DORI has increased in recent years as its value in enhancing the display, and data capture of terrain, obstacles, and airport mapping features has been recognized. In the future, DORI is planned to be used for synthetic vision systems, in glass cockpits, particularly during all weather operations. Figure B-4 shows an example of combination between DTM, DORI, 3D objects, textures, and metadata for 3D scene visualization.

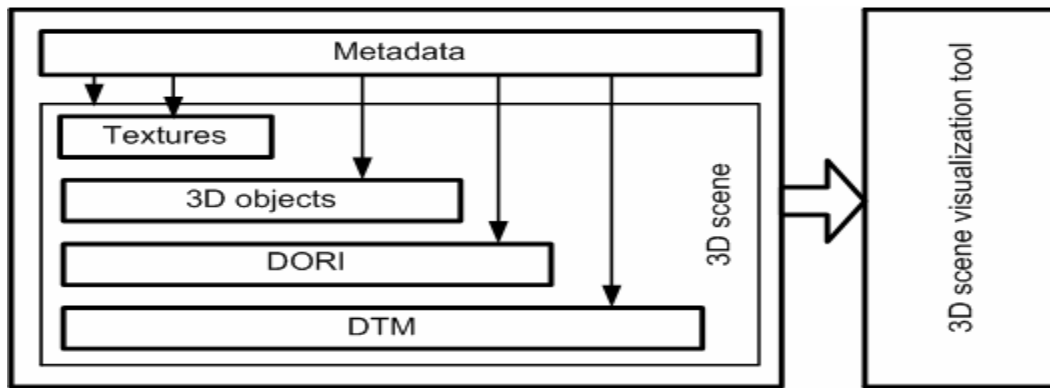


Figure B-4. DTM, DORI, 3-D objects, textures, and metadata for 3-D scene visualization

DORI is produced from aerial or satellite images by matching digital photo imagery to ground map coordinates using image processing software or GIS systems. DORI is imagery which has been georectified, or referenced to ground map coordinates, and adjusted for the effects of terrain undulation. The importance of this process is that map data can be displayed on top of its corresponding aerial image location, assuming that both map and image data have been registered to the same map coordinate system. For the DORI development process, it is necessary to specify:

- Type of imagery survey
- Scale of surveying
- Control points location, and number of points
- DTM development methodology, and DTM type
- Output formats

In a case when DORI and 3D scenes will become aeronautical information part, DORI processing should conform to this document for tracing data quality from source to end.

Data quality requirements for DORI depend upon end-user requirements. The main consideration is the spatial resolution of the imagery, that is, the size of the smallest resolvable feature on the image. For example, an aeronautical application that views the land surface from a great height requires imagery of a coarser resolution than a ground-based visualization. An en-route application may require DORI with 10 m resolution or lower, for example, while a taxi positional awareness application may require DORI with sub-meter resolution or better.

As with any geospatial data, it is important to deliver metadata about the imagery when distributing DORI. When DORI is delivered, information that should accompany the files should include:

- Detailed descriptions about the camera system that took the original imagery
- The spatial resolution of the original imagery
- The processing steps that accomplished the DORI
- The spatial resolution of the final output imagery
- Accuracy assessments of the final imagery

Metadata may include information about objects in the 3D scene, information about whom to contact for more information about the data or to acquire additional copies. For a full discussion of metadata, see the ISO 19115 specification.

Appendix C: Data Quality

C.1 Quality Management

C.1.1 Introduction

Guidance material relating to the validation of data is provided in this appendix. The basic principle is that if less attribute information is available from the early stages, then more effort to demonstrate validity will be required. Various types of errors that can affect the quality of a database are also described in this appendix.

C.1.1.1 Data correctness

In most cases, the required data quality will depend on the intended use of the data and the system in which the data resides. One approach to illustrating this concept is to consider multiple levels of data quality that correspond to the application's criticality (or impact on safety). Consider the following five severity levels caused by a loss of system integrity due to data errors:

1. Data errors could cause or contribute to the failure of a system function resulting in a *catastrophic* failure condition. A catastrophic failure condition would result in multiple fatalities of the occupants, or incapacitation or fatality of a flight crew member normally associated with the loss of the airplane. For example, the AMDB is used by a system to provide guidance to an automatic landing system or one obstacle data set is used to calculate minimum altitudes during the final approach to an aerodrome.
2. Data errors could cause or contribute to failure of a system function resulting in a *hazardous/severe-major* failure condition. A severe-major failure condition means that: (a) there is a large reduction in safety margins or functional capabilities, or (b) physical distress or higher workload such that the flight crew could not be relied upon to perform their tasks reliably or completely, or (c) adverse affects on people including serious or potentially fatal injuries to a small number of people. For example, the AMDB is used by a system to provide information to the flight crew to help steer the aircraft within the confines of the runway prior to take-off in low visibility conditions.
3. Data errors could cause or contribute to failure of a system function resulting in a *major* failure condition. A major failure condition means that: (a) there is a significant reduction in safety margins or functional capabilities, or (b) a significant increase in operator workload or reduction in operator efficiency, or (c) discomfort to people involved, possibly including injuries. For example, the AMDB is used by a system that provides warning information to the flight crew of a potential hazard on the aerodrome surface.
4. Data errors could cause or contribute to failure of a system function resulting in a *minor* failure condition. This condition means that: (a) there is a slight reduction in safety margins or functional capabilities, or (b) a slight increase in operator workload or reduction in operator efficiency, or (c) inconvenience to other people involved, possibly including injuries. For example, an AMDB is used by a system to provide information to the flight crew such that they are aware of the area on the aerodrome surface within which the aircraft can manoeuvre. It may be used for low speed --air

traffic control has provided to manoeuvre the aircraft on the aerodrome surface in visual conditions.

5. Data errors have *no affect* on safety, that is, failure conditions that would not affect the operational capability of the airplane or increase crew workload. For example, an AMDB is used only for planning purposes and there is a back-up means for the flight crew to receive the information. If the system is unavailable, the flight crews are able to reference paper charts on-board the aircraft to continue the operation.

Note: The above examples given for each level have not been fully developed for all cases and actual severity levels would be determined at the aircraft level in the functional hazard assessment.

C.1.1.2 Completeness

Not all applications will require a “complete” set of data to enable their intended use. That is, not all data types may be necessary for certain applications. Only a complete set of data can ensure that all of the envisioned applications can be implemented by system designers.

C.1.1.3 Connectivity and feature identification

For applications that require fully connected topologies, additional content may be required to identify interconnection points and to account for areas where there are no visual markings. For example, painted stand guidance lines from apron taxi lines to stand taxi lines may not exist. Data providers are not required to fill these gaps in order to meet the minimum requirements specified in this document. As a result, a fully connected topology may not be provided/available.

In addition, the minimum requirements specified in this document do not include unique identifiers for all features. Should this be required for a given application, agreement between the user and provider should consider this limitation. Interoperability between systems that use data sets from different providers cannot be guaranteed unless these issues are addressed at the implementation level.

C.1.2 Types of Errors

Geospatial databases are three-dimensional, expressing features in two spaces: horizontal and vertical. Two dimensions, latitude and longitude, are used to express the horizontal space location, while the elevation is used to express the vertical space location. When considering mapping data, the general error types described above take three basic forms of errors in the final product. The three forms of errors in these databases are: (a) incorrect horizontal location for an elevation value, (b) incorrect elevation for a horizontal location, or (c) both. These types of errors are the most important considerations when using the data. The three types of errors may be indistinguishable when the data is used, however, there are certain traits of these errors:

- Groups of data may share a common error, such as a translation error in which a geographic region or feature is displaced. In AMDBs, latitude/longitude errors are generally of more interest than elevation errors because data changes predominantly in the horizontal space (i.e. aerodromes are relatively flat). These location errors are generally a fundamental attribute of a data set, and are a result of the measurement techniques used when the data is taken, i.e. a *Systematic Error*. In general, it states that measurements and calculations should be carried to at least one more decimal place than will be required in the final value.
- Elevation errors may vary in an indistinguishable manner, i.e. a *Random Error*. This is another basic attribute of data sets, and is usually a function of the measurement equipment.

- Individual errors, i.e. *Blunders* may exist in the data set as evidenced by “spikes” in the data. These individual anomalies are, in general, easier to recognize than the systematic errors discussed above. Software in the user system may perform simple analyses to determine if the rate of change of data is higher than expected, thus sifting out these anomalous data points.

Modern information theory regards the observations as signals, the statistical properties of which are classified as having deterministic and stochastic components. This philosophy regards errors as properties of observations. Nevertheless, the classical theory considers errors as being of three types, namely: *Random Errors, Systematic Errors and Blunders*.

C.1.2.1 Random Errors

When talking of observational errors or random errors of observations, we refer to the basic inherent property that estimates of a random variable x do not agree, in general, with its expectation. Thus an observational error may in this context be defined as:

$$v_I = x_I - \mu_x,$$

with x_I = estimate I of the random variable x
 μ_x = population mean. (also for sample mean).

C.1.2.2 Systematic and Blunder Errors

Semantic errors are generally considered blunder errors. Examples include errors due to the misidentification of an object (e.g. a tower for a mast, a tree for a pole, a road for a railroad); errors due to misclassification of a theme (e.g. sand for clay); and errors due to incorrect attachment of attributes (e.g. length for width). These blunder errors will affect the consistency and reliability of data sets. Consistency checks are recommended when the initial data set is produced and again on each update.

The effects of systematic errors can be minimized via instrument calibration and/or the use of an appropriate mathematical model. From the statistical point of view it should be noted that *Systematic Errors* would affect all repeated observations in the same way. So they cannot be discovered by repetition of observations. An elimination of systematic errors can only be accomplished by the use of the appropriate mathematical model. Thus a triangle on the Earth's surface may be treated by one of the three functional models: plane, spherical, or ellipsoidal. The choice of one over the others will result in different values of systematic errors.

From the statistical point of view blunders, or mistakes, are observations that cannot be considered as belonging to the same sample from the distribution in question. Therefore they should not be used with other observations, and should be located and eliminated. In the advanced surveying practice statistical procedures, digital filters, etc. exist that are capable of locating and eliminating these errors.

C.1.3 Error Assessment

With regard to the treatment to be given to the above types of errors during terrain, obstacle or aerodrome mapping data acquisition for generation purposes, statistical methods should be applied in order to assess the random errors.

Digital filters based on statistical principles should be designed in order to locate and eliminate blunders. The surveying science has developed highly effective techniques for this purpose. Statistical test based on a corresponding probability density function of the measured or derived statistic, pre-adjustment data-snooping strategies, and simultaneous adjustments with robust estimators are advised for this purpose.

Deterministic procedures should be adopted to correct systematic errors, or the systematic errors should be taken into consideration in the derived statistics. Each data acquisition method introduces its own systematic effect or bias. To eliminate this effect or bias there are two recommended approaches:

1. use of an appropriate mathematical model that describes the systematic effect (e.g. Earth curvature, refraction, etc.)
2. use of extended functional models to account for a combination of systematic effects of known sources and quasi-random effects that are difficult to model. A typical example is the auto-calibration used in photogrammetric aero-triangulation.

3.

Either approach should be followed as necessary and according to the method and statistics involved.

C.1.3.1 Effect of errors on system integrity

System integrity is related to errors in that integrity can be compromised if errors in the database (data sets) exist and cannot be detected by the operational system. In a typical avionics system, techniques to boost system integrity are as follows:

- A thorough analysis, called a *Functional Hazard Assessment (FHA)*, is performed on the system to determine the failure modes that contribute to undesired top-level events. The integrity of the system cannot be understood until this analysis is completed. Using the output of the FHA, the system can be designed to eliminate or mitigate the effects of the failures contributing to the top-level events. Using architectural techniques such as system redundancy, perhaps even using dissimilar implementations, can increase system integrity. In general, redundancy allows comparison of system outputs and allows detection of system failure. Use of dissimilar implementations ensures that one implementation does not have a systemic flaw/error that could adversely affect integrity.
- The addition of monitoring and built-in-test equipment (BITE) functions allows detection of system failures. The effect of monitoring/BITE is to lower the probability of undetected failure/error, which in turn will increase system integrity.

The techniques listed above are not intended to be comprehensive. The intent is to highlight that data sets may contain undetectable errors, and these types of errors must be considered in the design of the system that uses an data set and the allowed operational uses of the system.

C.1.3.2 Errors that affect the confidence level of a data set

Confidence Level is a probability that the true value of the parameter in question is within a certain interval around the estimate. This probability is conventionally required to be 90%, 95%, or 99%, depending on how the data is to be used. Any type of error may affect the confidence level of a data set, but systematic and blunder errors will have a larger impact. Therefore, to achieve high confidence levels, it becomes critical to locate and eliminate these systematic and blunder-type errors if at all possible before the data become available to the end users. Methods to locate and eliminate these two types of errors have been outlined above.

There are mainly two methods of estimation that hold four important criteria *consistent, unbiased, efficient* and *sufficient*. They are the method of Maximum Likelihood and the method of Least Squares. The Maximum Likelihood method requires knowledge of the distribution from which the observations come for the purpose of parameter estimation. On the other hand, the method of Maximum Likelihood is more laborious from the computational point of view. The majority cases deal with normally distributed

observations. In this case the *Method of Least Squares* will give identical results to those of the *Method of Maximum Likelihood*.

With linear functions, the estimated parameters (in particular the estimated expectations) are consistent, unbiased, efficient, sufficient, and have the minimum variance property, especially when there is not systematic effects in the observations. Due to all above reasons, the method of Least Squares is recommended as the estimation method to use during all survey operations leading to a terrain and obstacle database.

The estimation of means, variance and covariance of random variables from sample data is referred to as point estimation, because it results in one value for each parameter in question. By contrast to point estimation, establishing confidence interval from sampling is referred to as interval estimation. After having performed point estimation – for instance, having estimated the coordinates of one point – the question remains:

How good is my estimation and how much can be relied on?

A simple answer is not possible because sampling never leads to the true theoretical distribution or its parameters. It is only possible to estimate probabilities with which the true value of the parameter in question is likely to be within a certain interval around the estimate. Such probability can be determined if we know the distribution function $f(x)$ of the random variable.

$$P(x_1 < x < x_2) = \int_{x_1}^{x_2} f(x) dx$$

By analogy, the probability statement for a confidence interval of the parameter s , is given by:

$$P(s_1 < s < s_2) = 1 - \alpha$$

where $(1 - \alpha)$ is called the Confidence Level.

The values s_1 and s_2 are the lower and the upper confidence limits for the parameter s . The above equation defines the confidence interval for the parameters as the interval around the estimate \hat{s} , such that the probability that this interval includes the (unknown) true value of the parameter is $(1-\alpha)$. The probability that the true value of the parameter does not fall in a given interval is the value α . The width of the confidence interval decreases as the degree of freedom increases and as the level of probability associated with it decreases.

Based on the above definitions we can conclude that the confidence level of a geospatial database is directly related with the lowest confidence level of existing random variables in the database.

C.1.4 Accuracy and precision

Precision may be defined as the degree of conformity among a set of observations of the same random variable. The spread (or dispersion) of the probability distribution is an indication of the precision. Therefore in Figure C-1, (2) is least precise and (3) is most precise.

Accuracy may be defined as the extent to which an estimate approaches its parameter (in conventional terms, it is considered as the degree of closeness to the “true” value). In Figure C-1, both (1) and (2) are equally accurate but neither is as precise as (3). By contrast, (3) is least accurate, although is the most precise.

The main difference between precision and accuracy lies in the possible presence of bias or systematic error. Although precision includes only random error, accuracy comprises both random and systematic errors. Both terms are used often with the same meaning. In surveying practice, for the majority of cases, the true value is not known and only a most probable value is estimated via random sample measurement procedures. All observed (random variables) or derived statistics should be qualified through their corresponding accuracy parameters such as mean, variance, standard deviation, and covariance.

A measure for accuracy proposed by Gauss is the “mean square error” (MSE) given by:

$$\text{MSE} = m^2 = E[(\hat{s} - E(\hat{s}))^2],$$

which it can be shown to reduce to:

$$\text{MSE} = m^2 = \sigma_s^2 + (\text{bias})^2$$

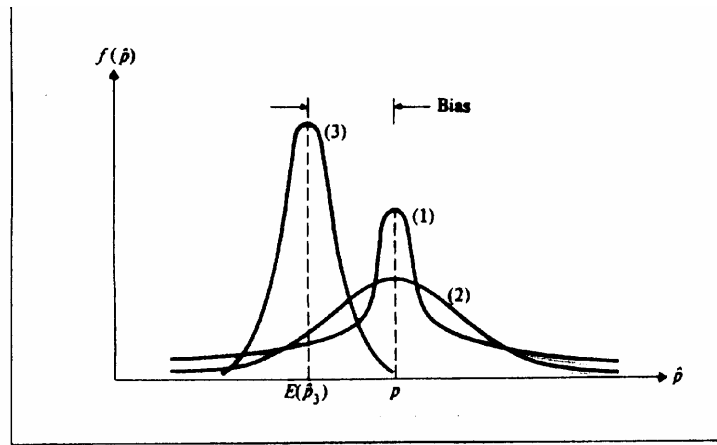


Figure C-1. Accuracy and precision

C.1.4.1 Resolution

There are many definitions for the term resolution. The definition given in Annex 15 and in this document states that resolution is the number of units or digits to which a measured or calculated value is expressed and used. However, other more specific definitions are used in surveying science and particularly in the field of image processing such as: spatial resolution, spectral resolution, radiometric resolution, and temporal resolution. It is important to note that for terrain, obstacles and aerodrome mapping data, not all features need to be measured or specified to the same resolution.

SPATIAL RESOLUTION is the capacity of the system (lens, sensor, emulsion, electronic components, etc.) to define the smallest possible object in the image. Historically, this has been measured as the number of line pairs per millimetre that can be resolved in a photograph of a bar chart. This is also called Analogue Resolution. For the modern photogrammetric cameras equipped with Forward Motion Compensation (FMC) devices and photogrammetric Panchromatic Black and White emulsions, this resolution can (depending on contrast) be 40 to 80 lp/mm (line pairs per millimetre). In the case of space scanner sensors mounted on satellite platforms, they record the incident radiation at a series of scan lines at approximately right angles to the flight direction of the platform. Within each scan line there is a set of recorded values called the picture elements or pixels, with each pixel being the same size as the IFOV (Instantaneous Field of View). The pixel is thus the measure of the spatial resolution limit of the scanner data.

SPECTRAL RESOLUTION is the capability of a sensor to discriminate the detected radiance in different intervals of wave lengths of the electromagnetic spectrum. Hence, the spectral resolution is determined by the number of bands that a particular sensor is capable to capture and by the corresponding spectral bandwidth. In general, a sensor will be more useful with more bands and with narrow spectral bands. The photographic systems have spectral bands covering from the panchromatic Black & White (B/W), the B/W infrared, to the natural colour or colour infrared. The electro-optic sensors typically have larger spectral resolution. For example, Spot imagery has three bands, the NOAA-AVHRR has five, and the Landsat TM has seven.

RADIOMETRIC RESOLUTION is the capability of the sensor to discriminate levels or intensity of spectral radiance. In analogue systems such as photography, the radiometric resolution is measured based on the number of grey levels that can be obtained. In opto-electronic systems, the radiance is recorded in an array of cells. A digit is assigned to each cell proportional to the received level of energy. This is done by an analogue to digital converter in the platform. Generally in the modern sensors the range is between 0 (zero) radiance into the sensor and 255 at saturation response of the detector.

TEMPORAL RESOLUTION is the rate at which a sensor can acquire a new image of the same spot of the Earth's surface. This depends on the altitude of the orbit and on the aperture angle of observation.

When utilising aerial photogrammetric means to capture data, the system resolution (i.e., combination of the optical resolution of the objective lens of the camera and resolving power of the emulsion) should be chosen based on the smallest feature that needs to be captured at the flying scale. If using satellite imagery, the selection of the bands to be used should be governed by the data elements to be captured and the size of the features to be mapped in order to derive the required spatial resolution of the imagery.

C.1.4.2 Timeliness Effects and Currency Errors

One of the most important attributes of a database is its currency. This informs the user of the date of its latest update or the effective date of the data. This information needs to be available at any time to the user. In the absence of continuously updating databases, changes that occur between updates will not be available as part of the database until the subsequent update. In the interim, these changes may be provided to users via a Notice to Airmen (NOTAM) or other means.

For some applications, aerodrome, terrain, and obstacle databases must be integrated. This integration of data is typically accomplished by layering of the various information sources into an information hierarchy that supports the application and associated display processing. The data that contributes to these layers is subject to varying levels of change, which in turn suggests that the data will be updated at different times, or in cycles of differing length. This inconsistency may result in unexpected database errors that can be difficult to detect by the system designer or the end user. For this reason, database suppliers and integrators are required to provide documentation on their timeliness and update process.

C.1.5 Traceability

Traceability is the ability to track the history, application or location of an entity by means of recorded identifications (Annex 15). More specifically, it is the degree to which a system or data product can provide a record of the changes made to that system or product and thereby enable an audit trail to be followed from the end user to the data originator.

The data originator, integrator, and/or provider must produce adequate information such that the traceability of a data set can be maintained according to the above definition and in accordance with defined quality procedures and processes. Typically, this can be accomplished with the provision of an appropriate data record or attribute for each data set element.

C.1.6 Quality Assurance

When originators, integrators, and system designers are unable to demonstrate compliance with the requirements of this appendix, the related data must require testing by using validation, logical consistency, or other means to be agreed upon by the organization that approves the application.

When multiple databases are employed for validation, the available metadata must be used to demonstrate independence of each data set. Two sets of measurements provided by the same source, using the same data collection technology may induce a bias, either in the initial collection, or in the post-processing techniques used for acquisition and sampling. Furthermore, differences between the data should be identified and compared to the requirements specified for the application.

C.2 Quality Evaluation

This section provides guidelines for evaluating quantitative quality information for geographic data interchange according to ISO 19113 principles.

Geo-spatial data sets are increasingly being shared, interchanged, and used for purposes other than their producers' intended ones. Information about the quality of available geographic data sets is vital to the process of selecting a data set in that the value of data is directly related to its quality. For the purpose of evaluating the quality of a data set, clearly defined procedures should be used in a consistent manner. The quality of a data set is described using two components, a *quantitative* component and a *non-quantitative* component. Complete descriptions of the quality of a data set will encourage the sharing, interchange, and use of appropriate geographic data sets. This enables data producers to express how well their product meets the criteria set forth in its product specification and data users to establish the extent to which a data set meets their requirements.

Quality Evaluation Procedures

A quality evaluation process should be used in different phases of a product life cycle, having different objectives in each phase. The phases of the life-cycle considered here are specification, production, delivery, use, and update.

The process for evaluating data quality is a sequence of steps to produce and report a data quality result. A quality evaluation process consists of the application of quality evaluation procedures to specific data set-related operations performed by the data set producer and the data set user. Processes for evaluating data quality are applicable to static data sets and to dynamic data sets.

The following are data set-related operations to which quality evaluation procedures are applicable.

1. When developing a product specification or user requirement, quality evaluation procedures should be used to assist in establishing conformance quality levels that should be met by the final product. A product specification or user requirement should include conformance quality levels for the data set and quality evaluation procedures to be applied during production and updating.
2. At the production stage, the producer should apply quality evaluation procedures, either explicitly established or not contained in the product specification, as part of the process of quality control. The description of the applied quality evaluation procedures, when used for production quality control, should be reported as lineage metadata, including, but not necessarily limited to, the quality evaluation procedures applied, conformance quality levels established, and the results.
3. On completion of the production, a quality evaluation process is used to produce and report data quality results. These results should be used to determine whether a data set conforms to its product specification. If the data set passes inspection, composed of a set of quality evaluation procedures, the data set is considered to be ready for use. The results of the inspection operation should be reported in

accordance with ISO 19113 (Quality Principles). The outcome of the inspection will be either acceptance or rejection of the data set. If the data set is rejected, then after the data has been corrected, a new inspection will be required before the product can be deemed to be in conformance with the product specification.

4. Quality evaluation procedures are used to establish the conformance quality levels for a data set to meet a user requirement. Indirect and/or direct methods may be used in analyses of data set conformance to user requirements. The results of the quality evaluation for conformance to user requirements should be reported as usage metadata for the data set.
5. Quality evaluation procedures should be applied to data set update operations, both to the items being used for update and to benchmark of the quality of the data set after update has occurred.

C.2.1 Applying quality evaluation procedures to dynamic data sets

Dynamic data sets are defined as data sets that receive updates frequently such that they are considered continuously updated. This is expected to be the case for most aeronautical data products described in this document. There are two basic ways to determine and report the quality of a dynamic data set: *benchmark* and *continuous* procedure.

The *benchmark* procedure is based on the establishment of a suitable reporting frequency, for example daily, weekly, or monthly, and making a copy of the data set at the reporting date. Then the copy is tested as if it were a static data set. This type of testing and reporting will provide quality of the data set as of the date/time of the copy.

The *continuous* procedure is based on testing the updates and evaluating the impact of the updates. This is equivalent to embedding the quality evaluation procedures given in ISO 19114 into a standard “process-oriented” procedure. Since this procedure can only provide current status of the quality of the updated items, it is necessary to combine both *benchmark* and *continuous* procedures to establish the quality for the updated data set.

The establishment of quality evaluation procedures should:

1. Identify applicable data quality elements and their associated data quality sub-elements, data quality scopes, data quality measure, and conformance quality levels to be used in the evaluation and reporting of the results.
2. Select the data quality evaluation method to be applied - the evaluation would then be on the updated feature and the relationship of that feature with the others within the data quality scope. In a continuous quality evaluation procedure only indirect or internal direct methods may be applied (e.g. is the update from a trusted source? does the update preserve topological consistency? does the updated feature retain logical consistency?).
3. Use the benchmark procedure to establish reference values of quality for the features and feature attributes to be checked during the continuous testing.
4. Integrate the continuous tests into the update process flow so that each proposed update is tested and accepted before it is introduced into a data set.
5. Dynamically update data quality results in integrating the continuous tests into the update process flow (i.e. each accepted update causes the current quality results to be adjusted accordingly). This allows immediate reports on data set quality to be generated.

Finally, the procedures should periodically re-establish the reference quality of the data set since all aspects of the quality of a data set may not be tested through a continuous process-based operation. For example, omission of features may not be found when only updated items are tested. The data set should be subject to periodic benchmark quality testing.

C.2.2 Reporting Data Quality

Quantitative quality results must be reported as metadata in compliance with ISO 19115, which contains the related model and data dictionary. There are two conditions under which a quality evaluation report should also be produced:

- » when data quality results reported as metadata are only reported as pass/fail
- » when aggregated data quality results are generated

The report is provided in the latter condition to explain how aggregation was done and how to interpret the meaning of the aggregate result. However, a quality evaluation report may be created at any other time, such as to provide more detail than reported as metadata, but a quality evaluation report cannot be used in lieu of reporting as metadata.

A quality evaluation report must be produced that contains the relevant model and data dictionary.

C.3 References

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Appendix D: Certification, Maintenance, and Temporal Considerations

D.1 Certification Guidelines

Use of terrain, obstacles and aerodrome mapping data sets in air navigation systems, presents new equipment design certification considerations for manufacturers and certification authorities. The overall integrity of the data sets is dependent upon the safety assessment of the function. This appendix provides guidance to suppliers and certification authorities.

Such guidance is provided because terrain, obstacles and aerodrome mapping data sets involve complex technology that is rapidly evolving, some future applications may require data of higher criticality than that available today, and many issues are not addressed by current airworthiness documents or existing guidance materials.

Adherence to the guidelines included in this appendix, in addition to the quality management requirements, should allow increasing reliance on terrain, obstacles and aerodrome mapping data. These guidelines should only be considered as one means, but not the only means, to demonstrate the acceptability of those data sets.

To satisfy certification requirements, the supplier must provide full traceability of data set generation.

There may be cases, where one or more of the earlier stages in the production of a data set are not available. This appendix outlines some of the issues that should be taken into account. The basic principle is that more verification and validation effort will be required if less evidence is available about the early stages of the data set generation.

The structure of the remainder of this appendix is divided into three sub-sections: terrain data sets, obstacle data sets, and the maintenance of databases.

D.2 Terrain Database Generation Phases

In developing a terrain database there are five phases as follows:

- Terrain data collection
- Mathematical transformations
- Database assembly
- Verification
- Validation

D.2.1 Terrain Data Collection

The terrain data collection phase covers the process of recording measurements and the actions performed on those measurements to create the initial terrain data. Some examples of methods of measurement are:

- Traditional in-situ surveys (e.g., using GPS) on the ground.
- Photogrammetric – the process of extracting or collecting digital data from a stereo image.
- Cartographic – a process of sampling and interpolation from lithographic hardcopy sources such as maps.
- Radar– from either aircraft or satellite.

Laser Altimeter – from either aircraft or satellite.

Synthetic Aperture Radar (SAR) interferometer – from either aircraft or satellite.

Some of these methods involve the use of complex mathematical techniques to minimize systematic errors. For example, in photogrammetry, mathematical techniques are used to reduce the distortion in the recorded images.

It is important to realize that each measurement method has weaknesses, which might lead to poor or unreliable data. The purpose of this appendix is not to list these weaknesses but to remind suppliers and airworthiness authorities that weaknesses exist so that compensatory actions can be described, taken and traced.

Each measurement method has its own established criteria to ensure data quality. These criteria should be recorded.

Validation of the data should begin with its acquisition. Metadata should be recorded to demonstrate integrity of the database, as required.

D.2.2 Mathematical Transformations

Once the measurements have been collected, mathematical and spatial transformations may be required to generate a terrain elevation model.

Transformation must be made to achieve a common reference system.

The purpose of the mathematical transformations may be one or more of the following:

- Transformation of measurement points to the appropriate post spacing: Spatial interpolation of the measurement points may not coincide with the desired reference position. Moving the horizontal location of measurements requires interpolation of the vertical elevation data.
- Transformation of the vertical and horizontal reference systems (datum). Data sets from multiple sources such as different countries or various measurement methods may use different reference systems.

To produce a complete set of terrain data over a given area may require the combination of several data sets and the identification of any gaps that remain.

Data sets that are to be merged must be pre-processed to have common attributes.

The data sets may contain invalid measurements that can be identified by inspections or mathematical tests. Some of these methods may allow correcting the errors. The following are principles to note:

For each of these transformations, the supplier must provide justification and demonstrate the validity of any assumptions that have been made. In particular, the effect of each of the transformations on the errors in the measurements needs to be understood and documented to provide a clear audit trail. Without this complete understanding the overall quality of the database cannot be determined.

Validation of the data should begin as early as possible in the database generation processes. This can be achieved by validating data after each transformation step.

If there is insufficient quality information available from the measurement phase or subsequent transformations, then the user of the data must make due allowance to compensate for the missing information.

D.2.3 Database Assembly

The output of the mathematical transformation process is the set of elevations and locations that describe a region, as well as the related quality information. The next step is to organize and format the data in

accordance with the requirements of the end-user. This may include filtering or systematic down-sampling of a data set.

D.2.4 Verification

The data to be included in a database must be verified at each stage of the origination/assembly process. Verification is defined as confirmation by examination and provision of objective evidence that specified requirements have been fulfilled (ref. Annex 15). This is necessary to ensure that the data set implementation accurately represents the developer's specifications and that the data set has not been corrupted in the assembly process.

The following verification techniques could be used:

Comparison of a sample of the data set points with samples from an independent measurement system. For example, GPS readings at specific points can be compared to the same points in a data set that was created by photogrammetric methods. The more samples that are checked, the higher the level of confidence in the quality of the data set.

Comparison of the terrain data set with other existing data sets. For this verification method, the vertical and horizontal reference datum for the data sets should be taken into account and the data sets should be independent.

Reasonableness checks to ensure that the terrain data set does not violate known properties of a terrain. Reasonableness checks ensure that the terrain data set does not violate known geographic extremes, such as the height of Mt Everest.

Comparison of the data set with independent measurements made during flight test.

D.2.5 Validation

It must be demonstrated that the data requirements defined by the application manufacturer have been validated.

Validation is defined as the confirmation by examination and provision of objective evidence that the particular requirements for a specific intended use are fulfilled (ref. Annex 15). The purpose of the validation process is to demonstrate that the data set has sufficient overall integrity to satisfy the airborne function's requirements for certification.

It is beneficial that the data set creation steps produce sufficient documentation to validate the use of the data set with the airborne function. It should be demonstrated that a representative subset of the data has been validated. The size and the distribution of the subset should be considered.

The following technique represents one means, but not the only one to achieve validation:

Demonstration by actual use of the data set in simulation or flight-tests.

Note: Other methods such as analysis applied at the beginning of the application development process could achieve these objectives as well.

D.3 Obstacle Database Generation Phases

In developing an obstacle database there are five phases as listed below:

1. Data collection
2. Mathematical transformations
3. Database assembly
4. Verification
5. Validation

D.3.1 Obstacle Data Collection

This phase covers the process of collecting relevant obstacle data. The collection is usually done by the relevant State organisations but may need to be augmented from other sources. Obstacle data that are derived from the same source material used for terrain are subject to the same considerations.

D.3.2 Mathematical Transformations

The conversion of a set of measurements to an obstacle data set can be a complex process. This is especially true since the obstacle location. Extent and height measurements may have varying levels of accuracy and resolution.

Reasons for obstacle data transformations are:

- Transformation of the reference system to align with a particular terrain database.
- Merging of several sources to produce a complete set of obstacle data over an area may require combining several data sets.

Data sets that are to be merged must be pre-processed to have common attributes. Identification of errors: the data sets may contain invalid measurements, which can be identified by inspections or mathematical tests. Some of these methods may allow correcting the errors. Obstacle data sets are subject to the same considerations as terrain data sets mentioned above.

D.3.3 Database Assembly

The output of the mathematical transformation process is the set of heights, extents and locations that describe a set of obstacles, as well as the related quality information. The next step is to organize and format the data in accordance with the requirements of the end-user. This may include filtering or systematic down-sampling of a data set.

D.3.4 Verification

The data to be included in a database must be verified at each stage of the origination/assembly process. Verification is defined as confirmation by examination and provision of objective evidence that specified requirements have been fulfilled (ref. Annex 15). This is necessary to ensure that the data set implementation accurately represents the developer's specifications and that the data set has not been corrupted in the assembly process.

The following verification techniques could be used:

- Comparison of a sample of the data set points with samples from an independent measurement system. For obstacle data sets, this could involve re-measurement of a sample of the obstacle collection by GPS readings. The more samples that are checked, the higher the level of confidence in the quality of the data set.
- Comparison of the obstacle data set with other existing data sets. For this verification method, the vertical and horizontal reference datum for the data sets should be taken into account and the data sets should be independent.
- Reasonableness checks to ensure that the obstacle data set does not violate known properties of obstacles, e.g. obstacles have positive heights.
- Comparison of the data set with independent measurements made during flight test.

D.3.5 Validation

It must be demonstrated that the data requirements defined by the application manufacturer have been validated. Validation is defined as the confirmation by examination and provision of objective evidence that the particular requirements for a specific intended use are fulfilled (ref. Annex 15). The purpose of the validation process is to demonstrate that the data set has sufficient overall integrity to satisfy the airborne function's requirements for certification.

It is beneficial that the data set creation steps produce sufficient documentation to validate the use of the data set with the airborne function. It should be demonstrated that a representative subset of the data has been validated. The size and the distribution of the subset should be considered.

The following technique represents one means, but not the only one to achieve validation:

- Demonstration by actual use of the data set in simulation or flight-tests.

Note: Other methods such as analysis applied at the beginning of the application development process could achieve these objectives as well.

D.4 Maintenance of Databases

Adherence to these procedures will ensure that the quality of the database is kept at an acceptable level.

Terrain and obstacle databases must 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 Annex 15, obstacle data should be updated in accordance with the AIRAC cycle amendment schedule. There is no update cycle specification for terrain data. Terrain databases must be updated as required and in accordance with their intended use.

Changes that occur within the AIRAC 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. Once the data has been correctly published or otherwise made available by the data originator, the data integrator must issue the updated database. The data integrators should issue the updated databases according to the AIRAC cycle. In addition, the integrator may provide a list of changes that have occurred since the previous issuance.

D.5 Data Set Maintenance and Update

Geographic data sets are increasingly being used in dynamic environments shared, interchanged, and used for purposes that require both accuracy and temporal relevance. How well a data set is managed is an indicator of how reliably it meets the criteria set forth in its product specification and assists a data user in determining a product's ability to satisfy the requirements for a particular application. The purpose of describing the maintenance and update criteria of geographic data is to facilitate the selection of the geographic data set best suited to application needs or requirements. Complete confidence in the maintenance and temporal quality of a data set will encourage the sharing, interchange, and use of appropriate geographic databases. Continuous maintenance and timely updates of geographic databases are vital to the aeronautical users of such databases.

The information in a geographical data set can be affected by three principal conditions:

1. when any quantity of data is deleted from, modified, or added to a data set
2. when a data set's product specification is modified
3. when the actual geography changes

The first condition, a modification to a data set, may occur quite frequently since many data sets in an existing database are not static. There is an increase in the interchange of information, therefore there is a corresponding increase in the use of data sets for multiple purposes and accompanying update and refinement of data sets to meet multiple purposes. If a database is likely to change with modifications to elements of the encompassed data sets, the quality of an overall database should be reassessed and updated as required when changes occur.

Complete knowledge of all applicable data quality elements and all data quality overview elements with the exception of the data quality overview element “usage” should be available when a data set is created. Only the data producer’s usage (assuming the data producer actually uses the data set) of a data set can initially be reported.

There is a reliance on data users to report uses of a database that differ from its intended purpose. In these cases continual updates to particular data elements should be made to reflect occurring, unforeseen uses.

The second condition, a modification to a data set’s product specification, is most likely to occur before initial database construction and prior to the release of the database. It is conceivable, however, that as a data set is used, its product specification is updated so that future modifications to the data set will better meet the actual need. As the product specification changes, the quality of the current data set also changes. The quality information for a data set should always reflect the current data set given its current product specification.

The third condition, a change in the actual geography, occurs continuously. Change may be caused by natural phenomena such as movements in the earth’s crust or erosion, but it is most often a result of human activity. Changes are often very rapid and dramatic. For this reason, the date of data collection is important when judging the quality of a data set. In some cases, when known, even the rate of change is of interest.

Throughout this document, various identified data elements are intended to represent the minimum necessary in the development and interchange of accurate geographical information to be used for aeronautical purposes. The purpose of this appendix is to review the process by which some of the mapping data is maintained and updated. The original application schema, as defined in the interchange format, is the basis of a successful data transfer and defines the possible content and structure of the transferred data, whereas the encoding rule defines the conversion rules for how to code the data into a system independent structure.

This appendix does not define any digital media, nor does it define any transfer services or transfer protocols. Additionally, this document will not specify periodicity of updates or temporal interchange requirements. Requirements for both are in accordance with Annex 15, Appendix 8.

Based on the scope for this document, the focus is on reviewing the maintenance processes associated with terrain, obstacle, and aerodrome mapping data. This section provides general high-level descriptions of the following processes:

- source analysis and evaluation procedures
- clarification of source anomalies procedures
- data input procedures
- data validation procedures
- data verification procedures

The information provided is in association with processes and procedures generally used by current source providers to properly manage and update data that is used in aeronautical applications (Figure D-1).

D.5.1 Source Analysis and Evaluation Procedures

Aeronautical, terrain and obstacle data are provided by various originating sources globally. Sources such as governments and international agencies, are some of the providers of raw, source data. As compiled by a producer for application usage, the source data must be analyzed for accuracy, format, and overall data quality, prior to being input into a certifiable aeronautical database. Consistent data analysis concepts provide an important framework for data producers and data users. A data evaluation procedure should describe, or reference documentation that describes, the methodology used to apply a data quality measure to the data specified by a data analysis scope and should include the reporting of the methodology. A data producer is then given the means for specifying how well the mapping used to create a data set reflects its universe of discourse. Data producers can then validate how well a data set meets the criteria set forth in its product specification.

Data users are given the means for assessing a data set derived from a universe of discourse identified as being coincident with requirements of a data user's application. Data users should assess quality to ascertain if a data set can satisfy the requirements of an application. This analysis usually involves a comparison of new data against duplicate sources and known or validated older versions of the same data set. Another validation technique would be against known and proven linear data sets, again for which there is a high degree of confidence. For instance, instrument approach procedures are designed and flown safely according to PANS-OPS design criteria. Procedure elevation surfaces could be built based on these criteria and procedure calculation and analysis could be made. Any discrepancies and anomalies that arise will then undergo a clarification process. Detailed source analysis aids in determining validity of the data and its usability.

D.5.2 Clarification of Source Anomalies Procedures

Once the source has been analyzed, there may be anomalies that require further evaluation. The analysis will incorporate a process whereby data can be reviewed and any discrepancies can be resolved with originating data source. The process is intended to ensure that the data is completely compliant and correct. If clarification is needed, it must be accomplished and noted prior to the data being input into the database.

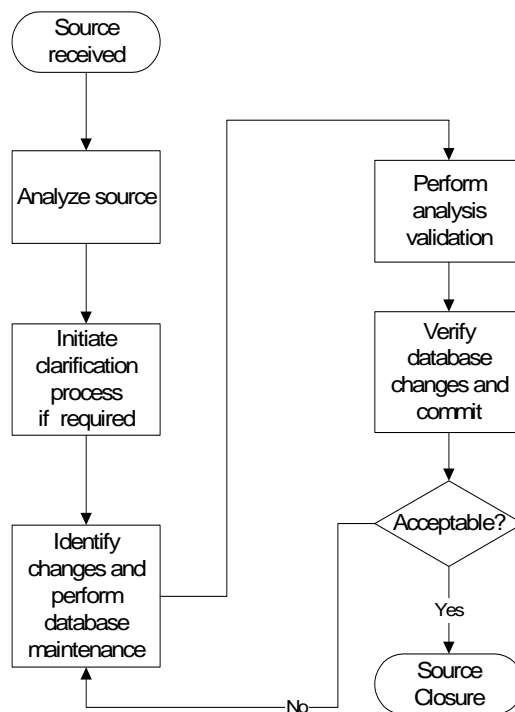


Figure D-1. Data management flow

D.5.3 Data Input Procedures

Once the source has been analyzed and any anomalies evaluated and corrected, the data can be input into the original or target database. The input data structure must be capable of representing data according to the specification in the application schema. It may be specific to a particular application schema or it may be generic, capable of representing data according to any schema. Data edits are then executed and any errors corrected before the data set can be validated.

D.5.4 Data Validation Procedures

Once the data is entered in the database, some validation procedures are performed to ensure the data is correct. These procedures provide the steps to confirm that the source was analyzed, annotated, and reported correctly to the product line.

D.5.5 Data Verification Procedures

The purpose of this process is to ensure that data is correctly entered before it is committed to the database. This step could involve an independent check to ensure data was entered correctly or a blind re-key and compare process.

D.5.6 Update Mechanism

An update mechanism allows previously interchanged data to be brought up to date without the need for re-issuing a complete new data set. Policies and procedures for updates are usually application-oriented and will follow specific architectural structures.

However, three basic update primitives are usually defined: *add*, *modify* and *delete*. These primitives work on the object level, but may also be defined to work on the attribute or association level. Any object that has previously been transmitted with a Universal Unique Identifier (UUID) may be modified or deleted. An update data set contains an ordered sequence of update primitives. The basic primitives are described as follows.

- a) **Add:** A new object has been added to the source data set and must be added into the target data set. An “add” primitive must contain information about the new object to be added and may contain information about where it is inserted in the target data set.
- b) **Modify:** An existing object has been modified in the source data set and must be modified in the target data set. A modify primitive must contain information that identifies the target object and the actual modifications. Examples of modification information could range from a complete object to just an updated attribute.
- c) **Delete:** An existing object has been deleted in the source data set and must therefore be deleted in the target data set. The delete primitive must contain information that identifies the target object to be deleted.

The original set of encoding rules should specify whether an update mechanism is required or not. If an update mechanism is required, the encoding rule should specify the different update primitives supported and how they refer to existing objects by UUIDs to convey update information.

D.6 Temporal Considerations

This section discusses some of the temporal concepts, as extracted from ISO 19108, needed to describe the temporal characteristics of geographic information. Temporal characteristics are normally associated with the following geographic information:

- » feature attributes
- » feature operations
- » feature relationships
- » metadata

Each has a function or value that could have a value in the temporal domain. The following paragraphs provide a basis for defining temporal feature attributes, feature operations, and feature relationships, and for defining the temporal aspects of metadata as it pertains to terrain, obstacle, and aerodrome mapping data products.

D.6.1 Temporal Scales

Time is measured on two scales, ordinal and interval. An ordinal scale provides information about relative position in time, while an interval scale offers a basis for measuring duration. Historically, temporal characteristics of features have been treated as thematic feature attributes. For example, a feature “building” may have an attribute “date of construction”.

However, there is increasing interest in describing the behaviour of features as a function of time. This can be supported to a limited extent when time is treated independently of space. For example, the path followed by a moving object can be represented as a set of features called “waypoints”, each of which is represented as a point and has an attribute that provides the time at which the object was at that spatial position.

Further, behaviour in time may be described more easily if the temporal dimension is combined with the spatial dimensions, so that a feature can be represented as a spatio-temporal object. For example, the path of a moving object could be represented as a curve described by coordinates in x, y, and t (time).

D.6.2 Temporal Characteristics

Static temporal characteristics are of two kinds: events and states. An event is an action that occurs at an instant. In fact, almost every event occupies a short interval of time, but when that interval is short relative to the scale of measurement, it is specified as an instant. A state is a condition – a characteristic of a feature or data set that persists for a period. The characteristics of the state should be described by one or more attributes of the class. Its recurrence should be indicated by the multiplicity at the attribute end of its association with the feature type class. Often, a change in state is associated with an event that initiates or terminates the state. That event should be identified by an attribute of the class that represents the state.

Note, an event may recur at multiple instants; a state may also recur at multiple times. The Feature Attribute Type cardinality should specify the number of recurrences that the application schema allows.

Events or states often occur or repeat on a regular basis. The duration of the interval between two successive occurrences of an event or state is its periodic time. When a temporal feature attribute describes a recurrent phenomenon, it should be defined in an application schema that is associated with a feature type class. This class should have at least two attributes: one that identifies a specific instant at which the event occurs or a period during which the thematic value of the attribute applies, and one which identifies the periodic time between occurrences of the event or state.

Feature relationships may involve time in two ways. Some feature relationships exist because of the temporal characteristics of the related feature instances. Other feature relationships, which may exist for variety of reasons, have their own temporal characteristics as relationships.

D.6.3 Temporal Feature Relationships

A temporal feature relationship is an explicit description of a relationship between the life spans of the features linked by the relationship. For example: construction of a taxiway that joins an existing runway and apron would have temporal impact on the operational status of the runway for a specified period of time.

If temporal feature relationships are important to an application, the application schema should assign a life span attribute to each feature type that it specifies. The attribute life span may be used when temporal positions are described in terms of either a calendar and clock or a temporal coordinate reference system.

For the purposes of this document, there are two subtypes of temporal feature relationships: simple temporal feature relationships and succession relationships.

Simple temporal feature relationships

A simple temporal feature relationship identifies the relative position in time of two or more features, and nothing else. In principle, this type of relationship exists between all feature instances, but cannot be predicated for any particular feature type.

According to the rules for application schemas defined in ISO 19109, feature relationships will normally be instantiated as associations between UML classes that represent feature types. However, purely temporal feature relationships are usually independent of feature type. Instantiation of temporal feature

relationships as associations between feature type classes may be appropriate if an application is only concerned with temporal feature relationships between certain types of features. This would be inefficient for an application schema that needs to carry information about some type of temporal relationship between instances of all feature types. It would be better for an application schema to support derivation of these relationships.

An alternative would be to instantiate a feature class that is a super-type for all feature type classes in the schema, and instantiate the feature relationship as a self-referent association at that level.

Feature Succession

Feature succession is the replacement of one set of features by another set. Replacement implies that the life spans of the first set of features come to an end at the instant when the life spans of the second set of features begin. For example: the conversion of a taxiway to a runway.

There are both spatial and temporal aspects to feature succession, in that the features in the relationship occupy the same spatial location, at different times and in a particular order. Feature succession is not always type dependent. That is, the type of a feature instance is not always a predictor of the type of the feature instance that replaces it. Feature succession can be modeled at the generic feature level, but not always at the feature type level.

There are three kinds of feature succession: feature substitution, feature division, and feature fusion. Feature substitution is the replacement of one feature instance by another feature instance of the same or a different feature type. It establishes a one-to-one relationship between two feature instances. Feature division occurs when a single feature instance separates into two or more feature instances of the same type. It establishes a one-to-many relationship between feature instances. Feature fusion occurs when two or more feature instances of the same type merge into a single feature instance. It establishes a many-to-one relationship between feature instances. A single event may result in a form of succession that is a combination of these types.

An example of division and substitution would be clearing part of a forest and replacing it with an aerodrome. An example of substitution and fusion would be clearing a forest adjacent to an aerodrome and using the area for a new runway.

Change in the characteristics of a single feature is not, in itself, feature succession. For example, consider a feature type Building that has an attribute “number of occupants”. The value of this attribute might be updated on a regular basis, but this would not be considered a replacement of one instance of Building by another instance of Building. The degree of change that is necessary before one instance of a feature type is considered to have replaced an earlier instance of the same feature type depends upon the application. As a general rule, replacement may be considered to have occurred when the feature identifier changes.

Temporal feature relationships of the feature succession type may also be instantiated in an application schema as associations between feature type classes, or as self-referent associations of a generic feature class. The names, roles, and multiplicities will be different for each type of succession. The role names should indicate the order in which one feature succeeded another. To include the time at which succession occurred, an application schema should represent the succession relationship as an association class with an attribute that identifies the time of occurrence.

D.6.4 Temporal Characteristics of Feature Relationships

Temporal characteristics of feature relationships usually provide information about the instant at which a relationship began or ended, or about the period for which it persisted. Like temporal feature attributes or temporal metadata elements, they describe events or states. Feature relationships that have temporal characteristics must be referenced as association classes. The temporal characteristic must be represented as an attribute.

D.6.5 Temporal Metadata Elements

ISO 19115 defines a set of standard metadata elements for geographic information. It also specifies a methodology for defining additional metadata elements within an application schema. Temporal metadata elements are similar to temporal feature attributes. Both describe a static characteristic – an event or a state – associated with a temporal position. They differ in that feature attributes describe characteristics of an object of data. The scope of the data described by a metadata element may range as abstracted in the feature instance, while metadata elements describe characteristics from a collection of data sets to a single characteristic of a feature.

When a temporal metadata element describes an event, the name and the definition should identify the action and the resolution to which its temporal position is specified. When a temporal metadata element describes a state, the name and the definition should describe the characteristics of the state. If the temporal reference system is not a combination of the Gregorian calendar and UTC, the definition must identify the temporal reference system that is used.

D.6.6 Sample Conformance Criteria

Example: Application schema for data interchange

An application schema should be verified to ensure that temporal attributes, temporal feature relationships, and temporal metadata elements are in compliance with specified requirements. The following steps are a recommended sample set for conformance verification:

- » Inspect the presentation of the temporal attributes and temporal relationships of features included in the application schema to ensure that the definitions satisfy requirements for the use of temporal objects to represent temporal attributes or their values.
- » Ensure that any temporal metadata elements defined in the application schema satisfy requirements.
- » Ensure that all required attributes and associations of temporal objects are implemented, and that optional attributes or associations are implemented in compliance with requirements.
- » Verify that required data types are used for values of temporal position

Appendix E: Example of a Data Product Specification

This appendix provides an example of an aerodrome mapping DPS. The example is represented both graphically and in XML and uses non-normative tag names.

Scope Information

Graphical Representation:

SpecificationScope	
ScopeIdentification	Airport Mapping Database Exchange (DO-272/ED-99)
level	005
levelName	
Extend	
description	Airport: EDDF, Date: 24.11.2003
levelDescription	
Coverage	area around an airport as specified in DO-272/ED-99

Example in XML:

```

<SpecificationScope>
  <ScopeIdentification>Airport Mapping Database Exchange (this
  document)</ScopeIdentification>
  <level>005</level>
  <levelName />
  <Extend>
    <description>Airport: EDDF, Date: 24.11.2003</description>
  </Extend>
  <levelDescription />
  <Coverage>area around an airport as specified in this document</Coverage>
</SpecificationScope>

```

Identification information

Graphical Representation:

IdentificationInformation	
Title	Airport Mapping Databases Exchange File
alternateTitle	
Abstract	DO-272/ED-99 compliant airport information
Purpose	exchange airport mapping databases
TopicCategory	018
spatialRepresentationType	001
spatialResolution	
geographicDescription	
geographicIdentifier	
code	EDDF
supplementalInformation	

Example in XML:

```
<IdentificationInformation>
<Title>Airport Mapping Databases Exchange File</Title>
<alternateTitle></alternateTitle>
<Abstract> This document compliant airport information</Abstract>
<Purpose>exchange airport mapping databases</Purpose>
<TopicCategory>018</TopicCategory>
<spatialRepresentationType>001</spatialRepresentationType>
<spatialResolution></spatialResolution>
<geographicDescription><geographicIdentifier><code>EDDF</code></geographicIdentifier></geographicDescription>
<supplementalInformation></supplementalInformation>
</IdentificationInformation>
```

Coverage Identification (Terrain only)

Graphical Representation:

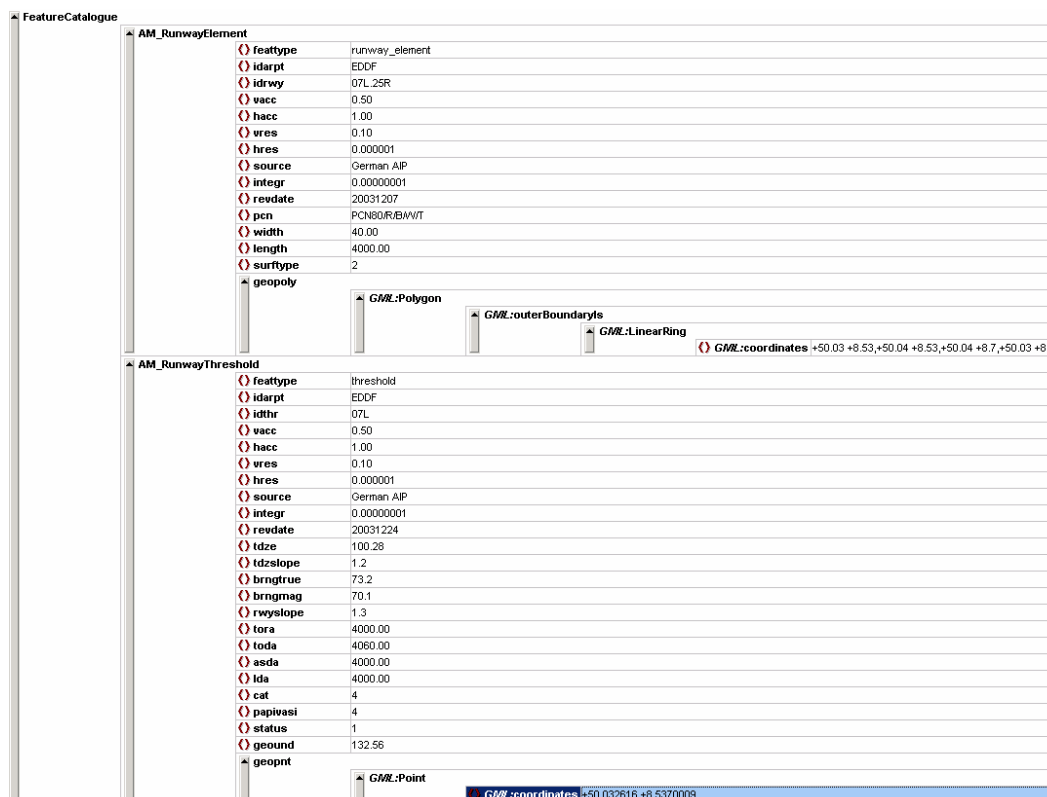
CoverageIdentification	
coverageID	24567
coverageDescription	N49 to N51, E008 to E009
coverageType	grid
specification	

Example in XML:

```
<CoverageIdentification>
<coverageID>24567</coverageID>
<coverageDescription>N49 to N51, E008 to E009</coverageDescription>
<coverageType>grid</coverageType>
<specification>Not available</specification>
</CoverageIdentification>
```

Feature Catalog

Graphical Representation:



Example in XML:

```
<FeatureCatalog>

  <AM_RunwayElement>
    <featype>runway_element</featype>
    <idarpt>EDDF</idarpt>
    <idrwy>07L.25R</idrwy>
    <vacc>0.50</vacc>
    <hacc>1.00</hacc>
    <vres>0.10</vres>
    <hres>0.000001</hres>
    <source>German AIP</source>
    <integr>0.00000001</integr>
    <revdate>20031207</revdate>
    <pcn>PCN80/R/B/W/T</pcn>
    <width>40.00</width>
    <length>4000.00</length>
    <surftype>2</surftype>
    <geopoly>
      <GML:Polygon>
        <GML:outerBoundaryIs>
          <GML:LinearRing>
            <GML:coordinates>+50.03 +8.53,+50.04 +8.53,+50.04 +8.7,+50.03 +8.7
          </GML:LinearRing>
        </GML:outerBoundaryIs>
      </GML:Polygon>
    </geopoly>
  </AM_RunwayElement>

  <AM_RunwayThreshold>
    <featype>threshold</featype>
    <idarpt>EDDF</idarpt>
    <idthr>07L</idthr>
    <vacc>0.50</vacc>
    <hacc>1.00</hacc>
    <vres>0.10</vres>
    <hres>0.000001</hres>
    <source>German AIP</source>
    <integr>0.00000001</integr>
    <revdate>20031224</revdate>
    <ldze>100.28</ldze>
    <ldzslope>1.2</ldzslope>
    <brngtrue>73.2</brngtrue>
    <brngmag>70.1</brngmag>
    <rwayslope>1.3</rwayslope>
    <tora>4000.00</tora>
    <toda>4060.00</toda>
    <asda>4000.00</asda>
    <lda>4000.00</lda>
    <cat>4</cat>
    <papivasi>4</papivasi>
    <status>1</status>
    <geound>132.56</geound>
    <geopnt>
      <GML:Point>
        <GML:coordinates>+50.032616 +8.5370009
      </GML:Point>
    </geopnt>
  </AM_RunwayThreshold>
</FeatureCatalog>
```

```

<GML:coordinates>+50.03 +8.53,+50.04 +8.53,+50.04 +8.7,+50.03
+8.7</GML:coordinates>
</GML:LinearRing>
</GML:outerBoundaryIs>
</GML:Polygon>
</geopoly>
</AM_RunwayElement>

<AM_RunwayThreshold>
<featype>threshold</featype>
<idarpt>EDDF</idarpt>
<idthr>07L</idthr>
<vacc>0.50</vacc>
<hacc>1.00</hacc>
<vres>0.10</vres>
<hres>0.000001</hres>
<source>German AIP</source>
<integr>0.00000001</integr>
<revdate>20031224</revdate>
<tdze>100.28</tdze>
<tdzslope>1.2</tdzslope>
<brngtrue>73.2</brngtrue>
<brngmag>70.1</brngmag>
<rwyslope>1.3</rwyslope>
<tora>4000.00</tora>
<toda>4060.00</toda>
<asda>4000.00</asda>
<lda>4000.00</lda>
<cat>4</cat>
<papivasi>4</papivasi>
<status>1</status>
<geound>132.56</geound>
<geopnt>
<GML:Point>
<GML:coordinates>+50.032616 +8.5370009</GML:coordinates>
</GML:Point>
</geopnt>
</AM_RunwayThreshold>

</FeatureCatalog>

```

Reference system information

Graphical Representation:



Example in XML:

```
<ReferenceSystem>
  <spatialReferenceSystem>
    <referenceSystemIdentifier>
      <name>
        <code>WGS84</code>
      </name>
    </referenceSystemIdentifier>
  </spatialReferenceSystem>
</ReferenceSystem>
```

Data quality information

Graphical Representation:

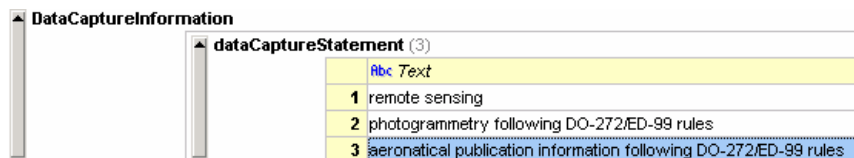


Example in XML:

```
<QualityIdentification>
  <dataQuality>
    <scope>
      <level>data set</level>
    </scope>
  </dataQuality>
</QualityIdentification>
```

Data capture information

Graphical Representation:



Example in XML:

```
<DataCaptureInformation>

  <dataCaptureStatement>remote sensing</dataCaptureStatement>
  <dataCaptureStatement>photogrammetry this document
  rules</dataCaptureStatement>
  <dataCaptureStatement>AIP following this document
  rules</dataCaptureStatement>

</DataCaptureInformation>
```

Maintenance information

Graphical Representation:

MaintenanceInformation	
maintenance_and_update_frequency	005

Example in XML:

```
<MaintenanceInformation>
<maintenance_and_update_frequency>005</maintenance_and_update_frequency>
</MaintenanceInformation>
```

Additional information

Not applicable

Metadata

Graphical Representation:

Metadata	
mdContact	
rpIndName	
rpOrgName	NIMA
rpPosName	
rpCntInfo	
cntAddress	
delPoint (2)	
	1 6500 Smith Lane
	2
city	Englewood
adminArea	Colorado
postCode	80112
country	USA
eMailAdd	
role	
mdDateSt	2003-12-08
RoleCd	005
refSysInfo	
RefSystem	
refSysID	
identCode	NAD83
dataIdInfo	
idCitation	
resTitle	JOD031208
resRefDate	
refDate	Text
dateType	
DateTypCd	002
idAbs	Aeronautical obstacles.
dataLang	
languageCode	en
tpCat	
TopicCatCd	018
geoBox	
westBL	98
eastBL	121
southBL	38
northBL	48
horzUnits	decimalDegrees
vertUnits	feet
spatReplInfo	
VectSpatRep	
topLvl	002
geometObjs	004

Example in XML:

```
<Metadata>
  <mdContact>
    <rpIndName/>
    <rpOrgName>NIMA</rpOrgName>
    <rpPosName/>
    <rpCntInfo>
      <cntAddress>
        <delPoint>6500 Smith Lane</delPoint>
        <delPoint/>
        <city>Englewood</city>
        <adminArea>Colorado</adminArea>
        <postCode>80112</postCode>
        <country>USA</country>
        <eMailAdd/>
      </cntAddress>
    </rpCntInfo>
    <role>
      <RoleCd>005</RoleCd>
    </role>
  </mdContact>
  <mdDateSt>2003-12-08</mdDateSt>
  <refSysInfo>
    <RefSystem>
      <refSysID>
        <identCode>NAD83</identCode>
      </refSysID>
    </RefSystem>
  </refSysInfo>
  <dataIdInfo>
    <idCitation>
      <resTitle>JOD031208</resTitle>
      <resRefDate>
        <refDate>Text</refDate>
        <dateType>
          <DateTypCd>002</DateTypCd>
        </dateType>
      </resRefDate>
    </idCitation>
    <idAbs>Aeronautical obstacles.</idAbs>
    <dataLang>
      <languageCode>en</languageCode>
    </dataLang>
    <tpCat>
      <TopicCatCd>018</TopicCatCd>
    </tpCat>
    <geoBox>
      <westBL>98</westBL>
      <eastBL>121</eastBL>
      <southBL>38</southBL>
```

```
        <northBL>48</northBL>
      </geoBox>
    </dataIdInfo>
    <horzUnits>decimalDegrees</horzUnits>
    <vertUnits>feet</vertUnits>
    <spatRepInfo>
      <VectSpatRep>
        <topLvl>002</topLvl>
        <geomObj>004</geomObj>
      </VectSpatRep>
    </spatRepInfo>
  </Metadata>
```

Appendix F: Metadata Elements

Tables F-1 through F-9 provide a glossary for the metadata elements required by this guidance in paragraphs 2.12, 3.12, and 4.12. Columns with headings “T”, “O”, and “A”, indicate required elements for terrain, obstacle, and aerodrome mapping data products, respectively.

Table F-1. Metadata element descriptions – about the metadata

Metadata element	T	O	A	Description
Contact	✓	✓	✓	party responsible for the metadata information
DateStamp	✓	✓	✓	date that the metadata was created
Acquisition Method	✓			method used to acquire data
Horizontal Units	✓	✓	✓	units of measure for horizontal coordinates
Vertical Units	✓	✓	✓	units of measure for vertical coordinates
Recorded Surface	✓			indicates whether the data represents the bald earth surface, the first reflective surface, or somewhere in between
Penetration Level	✓			the approximate distance a radar or lidar acquisition method traveled into a foliage canopy before being reflected
Data Integrity	✓	✓	✓	the overall data processing integrity of the data product
Surface Type	✓			general comment indicating environmental aspects of the collected surface. (e.g. snow-covered)
Quality Classification			✓	indicates the data meets accuracy, resolution and integrity requirements

Table F-2. Metadata element descriptions – identification

Metadata element	T	O	A	Description
Citation	✓	✓	✓	citation data for the resource(s)
Abstract	✓			brief narrative summary of the content of the resource(s)
PointOfContact	✓	✓	✓	identification of, and means of communication with, person(s) and organizations(s) associated with the resource(s)
SpatialRepresentationTyp	✓			method used to spatially represent geographic information
SpatialResolution	✓			factor which provides a general understanding of the density of spatial data in the data set
Language	✓	✓	✓	language(s) used within the data set
TopicCategory	✓	✓	✓	main theme(s) of the data set
GeographicDescription	✓	✓		description of the geographic area within which data is available

Table F-3. Metadata element descriptions – quality

Metadata element	T	O	A	Description
Scope	✓	✓	✓	the specific data to which the data quality information applies
Report	✓			quantitative quality information for the data specified by the scope
Lineage	✓	✓	✓	non-quantitative quality information about the lineage of the data specified by the scope
ProcessStep	✓	✓	✓	information about an event in the creation process for the data specified by the scope
Source	✓			information about the source data used in creating the data specified by the scope
Description	✓	✓	✓	description of the event, including related parameters or tolerances
DateTime	✓	✓	✓	date and time or range of date and time on or over which the process step occurred
EvaluationMethodDesc	✓			description of the evaluation method
Result	✓			value (or set of values) obtained from applying a data quality measure or the out come of evaluating the obtained value (or set of values) against a specified acceptable conformance quality level
Specification	✓			citation of product specification or user requirement against which data is being evaluated
Explanation	✓			explanation of the meaning of conformance for this result
Pass	✓			indication of the conformance result where 0 = fail and 1 = pass
ValueType	✓			value type for reporting a data quality result
ValueUnit	✓			value unit for reporting a data quality result
ErrorStatistic	✓			statistical method used to determine the value
Value	✓			quantitative value or values, content determined by the evaluation procedure used
Lineage Statement		✓	✓	General statement concerning the lineage of the data.

Table F-4. Metadata element descriptions – maintenance

Metadata element	T	O	A	Description
MaintenanceAndUpdateFreq	✓	✓	✓	frequency with which changes and additions are made to the resource after the initial resource is completed
Maintenance Note		✓	✓	Explanation about maintenance of the resource
Contact		✓	✓	Contact person for information about maintenance of the resource

Table F-5. Metadata element descriptions – spatial representation

Metadata element	T	O	A	Description
NumberOfDimensions	✓			number of independent spatial-temporal axes
AxisDimensionsProperties	✓			information about spatial-temporal axis properties
CellGeometry	✓			identification of grid data as point or cell
TransformationParameterAvailability	✓			indication of whether or not parameters for transformation exists
DimensionName	✓			name of the axis
DimensionSize	✓			number of elements along the axis
Resolution	✓			degree of detail in the grid data set. Used as Post Spacing for grids.

Table F-6. Metadata element descriptions – reference system

Metadata element	T	O	A	Description
ReferenceSystemIdentifier	✓	✓	✓	name of reference system
Projection	✓			identity of the projection used
Ellipsoid	✓			identity of the ellipsoid used
Datum	✓			Identity of the datum used. Horizontal Datum
EllipsoidParameters	✓			set of parameters that describe the ellipsoid
Name	✓	✓		name of reference system used
AxisUnits	✓			units of the semi-major axis
DenominatorOfFlatteningRatio	✓			ratio of the difference between the equatorial and polar radii of the ellipsoid to the equatorial radius when the numerator is set to 1
Authority	✓	✓	✓	person or party responsible for maintenance of the namespace
Code	✓	✓	✓	alphanumeric value identifying an instance in the namespace
CodeSpace		✓	✓	Name or identifier of the person or organization responsible for the reference system identifier
Version		✓	✓	Version of the reference system being used

Note: Additional metadata elements are required for terrain databases when a projection is used (see ISO 19115).

Table F-7. Metadata element descriptions – distribution

Metadata element	T	O	A	Description
DistributorFormat	✓	✓	✓	provides a description of the format of the data to be distributed
DistributorContact	✓	✓	✓	party from whom the resource may be obtained. This list need not be exhaustive
Name	✓	✓	✓	name of the data transfer format(s)
Version	✓	✓	✓	Version of the format

Table F-8. Metadata element descriptions – extent

Metadata element	T	O	A	Description
Polygon	✓	✓	✓	Sets of points defining the bounding polygon
WestBoundLongitude	✓	✓	✓	western-most coordinate of the limit of the data set extent, expressed in longitude in decimal degrees (positive east)
EastBoundLongitude	✓	✓	✓	eastern-most coordinate of the limit of the data set extent, expressed in longitude in decimal degrees (positive east)
SouthBoundLatitude	✓	✓	✓	Southern-most coordinate of the limit of the data set extent, expressed in latitude in decimal degrees (positive north)
NorthBoundLatitude	✓	✓	✓	Northern-most, coordinate of the limit of the data set extent expressed in latitude in decimal degrees (positive north)
GeographicIdentifier	✓	✓	✓	Identifier representing a geographic area
ExtentTypeCode	✓	✓	✓	Identifies whether the bounding polygon encompasses an area covered by data or an area where data is not present. (Boolean value = 1 indicates inclusion)
MinimumValue	✓			lowest vertical extent contained in the data set
MaximumValue	✓			highest vertical extent contained in the data set
unitOfMeasure	✓			vertical units used for vertical extent information Examples: metres, feet, millimetres, hectopascals
VerticalDatum	✓			Provides information about the origin from which the maximum and minimum elevation values are measured
Description	✓	✓	✓	Spatial and temporal extent for the referring object.

Table F-9. Metadata element descriptions – citation and responsible party

Metadata element	T	O	A	Description
Title	✓	✓	✓	name by which the cited resource is known
Date	✓	✓	✓	reference date for the cited resource
CitedResponsibleParty	✓	✓	✓	name and position information for an individual or organization that is responsible for the resource
Role	✓	✓	✓	function performed by the responsible party
Individual Name	✓	✓	✓	
Organization Name	✓	✓	✓	
Delivery Point	✓	✓	✓	
City	✓	✓	✓	
Administration Area	✓	✓	✓	
Postal Code	✓	✓	✓	
Country	✓	✓	✓	
Electronic Mail Address	✓	✓	✓	
DateType	✓	✓	✓	event used for reference date
Voice	✓	✓	✓	telephone number at which to reach the responsible party by voice
Facsimile	✓	✓	✓	telephone number at which to reach the responsible party by facsimile

Appendix G: Metadata Code Lists and Enumerations

This appendix provides the stereotype classes “code list” and “enumeration” from ISO 19115 (Metadata), Chapter B.5. The enumerations are not extendable. The code lists can be extended using the rules specified in ISO 19115. Guidance for extending code lists is also provided at the end of this Appendix.

CI_DateTypeCode (Code List)

Name	Domain code	Definition
CI_DateTypeCode	DateTypCd	identification of when a given event occurred
creation	001	date identifies when the resource was brought into existence
publication	002	date identifies when the resource was issued
revision	003	date identifies when the resource was examined or re-examined and improved or amended

CI_OnLineFunctionCode (Code List)

Name	Domain code	Definition
CI_OnLineFunctionCode	OnFunctCd	function performed by the resource
download	001	online instructions for transferring data from one storage device or system to another
information	002	online information about the resource
offlineAccess	003	online instructions for requesting the resource from the provider
order	004	online order process for obtaining the resource
search	005	online search interface for seeking out information about the resource

CI_PresentationFormCode (Code List)

Name	Domain code	Definition
CI_PresentationFormCode	PresFormCd	mode in which the data is represented
documentDigital	001	digital representation of a primarily textual item (can contain illustrations also)
documentHardcopy	002	representation of a primarily textual item (can contain illustrations also) on paper, photographic material, or other media
imageDigital	003	likeness of natural or man-made features, objects, and activities acquired through the sensing of visual or any other segment of the electromagnetic spectrum by sensors, such as thermal infrared, and high resolution radar and stored in digital format
imageHardcopy	004	likeness of natural or man-made features, objects, and activities acquired through the sensing of visual or any other segment of the electromagnetic spectrum by sensors, such as thermal infrared, and high resolution radar and reproduced on paper, photographic material, or other media for use directly by the human user
mapDigital	005	map represented in raster or vector form
mapHardcopy	006	map printed on paper, photographic material, or other media for use directly by the human user
modelDigital	007	multi-dimensional digital representation of a feature, process, etc.
modelHardcopy	008	3-dimensional, physical model
profileDigital	009	vertical cross-section in digital form
profileHardcopy	010	vertical cross-section printed on paper, etc.
tableDigital	011	digital representation of facts or figures systematically displayed, especially in columns
tableHardcopy	012	representation of facts or figures systematically displayed, especially in columns, printed on paper, photographic material, or other media
videoDigital	013	digital video recording
videoHardcopy	014	video recording on film

CI_RoleCode (Code List)

Name	Domain code	Definition
CI_RoleCode	RoleCd	function performed by the responsible party
resourceProvider	001	party that supplies the resource
custodian	002	party that accepts accountability and responsibility for the data and ensures appropriate care and maintenance of the resource
owner	003	party that owns the resource
user	004	party who uses the resource
distributor	005	party who distributes the resource
originator	006	party who created the resource
pointOfContact	007	party who can be contacted for acquiring knowledge about or acquisition of the resource
principalInvestigator	008	key party responsible for gathering information and conducting research
processor	009	party who has processed the data in a manner such that the resource has been modified
publisher	010	party who published the resource
author	011	party who authored the resource

DQ_EvaluationMethodTypeCode (Code List)

Name	Domain code	Definition
DQ_EvaluationMethodTypeCode	EvalMethTypeCd	type of method for evaluating an identified data quality measure
directInternal	001	method of evaluating the quality of a data set based on inspection of items within the data set, where all data required is internal to the data set being evaluated
directExternal	002	method of evaluating the quality of a data set based on inspection of items within the data set, where reference data external to the data set being evaluated is required
indirect	003	method of evaluating the quality of a data set based on external knowledge

DS_AssociationTypeCode (Code List)

Name	Domain code	Definition
DS_AssociationTypeCode	AscTypeCd	justification for the correlation of two data sets
crossReference	001	reference from one data set to another
largerWorkCitation	002	reference to a master data set of which this one is a part
partOfSeamlessDatabase	003	part of same structured set of data held in a computer
source	004	mapping and charting information from which the data set content originates
stereoMate	005	part of a set of imagery that when used together, provides three-dimensional images

DS_InitiativeTypecode (Code List)

Name	Domain code	Definition
DS_InitiativeTypeCode	InitTypCd	type of aggregation activity in which data sets are related
campaign	001	series of organized planned actions
collection	002	accumulation of data sets assembled for a specific purpose
exercise	003	specific performance of a function or group of functions
experiment	004	process designed to find if something is effective or valid
investigation	005	search or systematic inquiry
mission	006	specific operation of a data collection system
sensor	007	device or piece of equipment which detects or records
operation	008	action that is part of a series of actions
platform	009	vehicle or other support base that holds a sensor
process	010	method of doing something involving a number of steps
program	011	specific planned activity
project	012	organized undertaking, research, or development
study	013	examination or investigation
task	014	piece of work
trial	015	process of testing to discover or demonstrate something

MD_CellGeometryCode (Code List)

Name	Domain code	Definition
MD_CellGeometryCode	CellGeoCd	code indicating whether grid data is point or area
point	001	each cell represents a point
area	002	each cell represents an area

MD_CharacterSetCode (Code List)

Name	Domain code	Definition
MD_CharacterSetCode	CharSetCd	name of the character coding standard used for the resource
ucs2	001	16-bit fixed size Universal Character Set, based on ISO/IEC 10646
ucs4	002	32-bit fixed size Universal Character Set, based on ISO/IEC 10646
utf7	003	7-bit variable size UCS Transfer Format, based on ISO/IEC 10646
utf8	004	8-bit variable size UCS Transfer Format, based on ISO/IEC 10646
utf16	005	16-bit variable size UCS Transfer Format, based on ISO/IEC 10646
8859part1	006	ISO/IEC 8859-1, Information technology – 8-bit single-byte coded graphic character sets – Part 1: Latin alphabet No. 1
8859part2	007	ISO/IEC 8859-2, Information technology – 8-bit single-byte coded graphic character sets – Part 2: Latin alphabet No. 2
8859part3	008	ISO/IEC 8859-3, Information technology – 8-bit single-byte coded graphic character sets – Part 3: Latin alphabet No. 3
8859part4	009	ISO/IEC 8859-4, Information technology – 8-bit single-byte coded graphic character sets – Part 4: Latin alphabet No. 4

Name	Domain code	Definition
8859part5	010	ISO/IEC 8859-5, Information technology – 8-bit single-byte coded graphic character sets – Part 5: Latin/Cyrillic alphabet
8859part6	011	ISO/IEC 8859-6, Information technology – 8-bit single-byte coded graphic character sets – Part 6: Latin/Arabic alphabet
8859part7	012	ISO/IEC 8859-7, Information technology – 8-bit single-byte coded graphic character sets – Part 7: Latin/Greek alphabet
8859part8	013	ISO/IEC 8859-8, Information technology – 8-bit single-byte coded graphic character sets – Part 8: Latin/Hebrew alphabet
8859part9	014	ISO/IEC 8859-9, Information technology – 8-bit single-byte coded graphic character sets – Part 9: Latin alphabet No. 5
8859part10	015	ISO/IEC 8859-10, Information technology – 8-bit single-byte coded graphic character sets – Part 10: Latin alphabet No. 6
8859part11	016	ISO/IEC 8859-11, Information technology – 8-bit single-byte coded graphic character sets – Part 11: Latin/Thai alphabet
(reserved for future use)	017	a future ISO/IEC 8-bit single-byte coded graphic character set (e.g. possibly 8859 part 12)
8859part13	018	ISO/IEC 8859-13, Information technology – 8-bit single-byte coded graphic character sets – Part 13: Latin alphabet No. 7
8859part14	019	ISO/IEC 8859-14, Information technology – 8-bit single-byte coded graphic character sets – Part 14: Latin alphabet No. 8 (Celtic)
8859part15	020	ISO/IEC 8859-15, Information technology – 8-bit single-byte coded graphic character sets – Part 15: Latin alphabet No. 9
8859part16	021	ISO/IEC 8859-16, Information technology – 8-bit single-byte coded graphic character sets – Part 16: Latin alphabet No. 10

Name	Domain code	Definition
jis	022	Japanese code set used for electronic transmission
shiftJIS	023	Japanese code set used on MS-DOS based machines
eucJP	024	Japanese code set used on UNIX based machines
usAscii	025	United States ASCII code set (ISO 646 US)
ebcdic	026	IBM mainframe code set
eucKR	027	Korean code set
big5	028	traditional Chinese code set used in Taiwan, Hong Kong of China and other areas
GB2312	029	simplified Chinese code set

MD_ClassificationCode (Code List)

Name	Domain code	Definition
MD_ClassificationCode	ClasscationCd	name of the handling restrictions on the data set
unclassified	001	available for general disclosure
restricted	002	not for general disclosure
confidential	003	available for someone who can be entrusted with information
secret	004	kept or meant to be kept private, unknown, or hidden from all but a select group of people
topsecret	005	of the highest secrecy

MD_CoverageContentTypecode (Code List)

Name	Domain code	Definition
MD_CoverageContentTypeCode	ContentTypCd	specific type of information represented in the cell
image	001	meaningful numerical representation of a physical parameter that is not the actual value of the physical parameter
thematicClassification	002	code value with no quantitative meaning, used to represent a physical quantity
physicalMeasurement	003	value in physical units of the quantity being measured

MD_DatatypeCode (Code List)

Name	Domain code	Definition
MD_DatatypeCode	DatatypeCd	Data type of element or entity
class	001	descriptor of a set of objects that share the same attributes, operations, methods, relationships, and behaviour
codelist	002	flexible enumeration useful for expressing a long list of values, can be extended
enumeration	003	data type whose instances form a list of named literal values, not extendable
codelistElement	004	permissible value for a code list or enumeration
abstractClass	005	class that cannot be directly instantiated
aggregateClass	006	class that is composed of classes it is connected to by an aggregate relationship
specifiedClass	007	subclass that may be substituted for its super class
datatypeClass	008	class with few or no operations whose primary purpose is to hold the abstract state of another class for transmittal, storage, encoding or persistent storage

Name	Domain code	Definition
interfaceClass	009	named set of operations that characterize the behaviour of an element
unionClass	010	class describing a selection of one of the specified types
metaclass	011	class whose instances are classes
typeClass	012	class used for specification of a domain of instances (objects), together with the operations applicable to the objects. A type may have attributes and associations
characterString	013	free text field
integer	014	numerical field
association	015	semantic relationship between two classes that involves connections among their instances

MD_DimensionNameTypeCode (Code List)

Name	Domain code	Definition
MD_DimensionNameTypeCode	DimNameTypCd	name of the dimension
row	001	ordinate (y) axis
column	002	abscissa (x) axis
vertical	003	vertical (z) axis
track	004	along the direction of motion of the scan point
crossTrack	005	perpendicular to the direction of motion of the scan point
line	006	scan line of a sensor
sample	007	element along a scan line
time	008	duration

MD_GeometricObjectTypeCode (Code List)

Name	Domain code	Definition
MD_GeometricObjectTypeCode	GeoObjTypCd	name of point or vector objects used to locate zero-, one-, two-, or three-dimensional spatial locations in the data set
complex	001	set of geometric primitives such that their boundaries can be represented as a union of other primitives
composite	002	connected set of curves, solids or surfaces
curve	003	bounded, 1-dimensional geometric primitive, representing the continuous image of a line
point	004	zero-dimensional geometric primitive, representing a position but not having an extent
solid	005	bounded, connected 3-dimensional geometric primitive, representing the continuous image of a region of space
surface	006	bounded, connected 2-dimensional geometric primitive, representing the continuous image of a region of a plane

MD_ImagingConditionCode (Code List)

Name	Domain code	Definition
MD_ImagingConditionCode	ImgCondCd	code which indicates conditions which may affect the image
blurredImage	001	portion of the image is blurred
cloud	002	portion of the image is partially obscured by cloud cover
degradingObliquity	003	acute angle between the plane of the ecliptic (the plane of the Earth's orbit) and the plane of the celestial equator
fog	004	portion of the image is partially obscured by fog
heavySmokeOrDust	005	portion of the image is partially obscured by heavy smoke or dust

Name	Domain code	Definition
night	006	image was taken at night
rain	007	image was taken during rainfall
semiDarkness	008	image was taken during semi-dark conditions—twilight conditions
shadow	009	portion of the image is obscured by shadow
snow	010	portion of the image is obscured by snow
terrainMasking	011	the absence of collection data of a given point or area caused by the relative location of topographic features which obstruct the collection path between the collector(s) and the subject(s) of interest

MD_KeywordTypeCode (Code List)

Name	Domain code	Definition
MD_KeywordTypeCode	KeyTypCd	methods used to group similar keywords
discipline	001	keyword identifies a branch of instruction or specialized learning
place	002	keyword identifies a location
stratum	003	keyword identifies the layer(s) of any deposited substance
temporal	004	keyword identifies a time period related to the data set
theme	005	keyword identifies a particular subject or topic

MD_MaintenanceFrequencyCode (Code List)

Name	Domain code	Definition
MD_MaintenanceFrequencyCode	MaintFreqCd	frequency with which modifications and deletions are made to the data after it is first produced
continual	001	data is repeatedly and frequently updated
daily	002	data is updated each day
weekly	003	data is updated on a weekly basis
fortnightly	004	data is updated every two weeks
monthly	005	data is updated each month
quarterly	006	data is updated every three months
biannually	007	data is updated twice each year
annually	008	data is updated every year
asNeeded	009	data is updated as deemed necessary
irregular	010	data is updated in intervals that are uneven in duration
notPlanned	011	there are no plans to update the data
unknown	012	frequency of maintenance for the data is not known

MD_MediumFormatCode (Code List)

Name	Domain code	Definition
MD_MediumFormatCode	MedFormCd	method used to write to the medium
cpio	001	CoPy In / Out (UNIX file format and command)
tar	002	Tape ARchive
highSierra	003	high sierra file system
iso9660	004	information processing – volume and file structure of CD-ROM
iso9660RockRidge	005	rock ridge interchange protocol (UNIX)
iso9660AppleHFS	006	hierarchical file system (Macintosh)

MD_MediumNameCode (Code List)

Name	Domain code	Definition
MD_MediumNameCode	MedNameCd	name of the medium
cdRom	001	read-only optical disk
dvd	002	digital versatile disk
dvdRom	003	digital versatile disk, read only
3halfInchFloppy	004	3,5 inch magnetic disk
5quarterInchFloppy	005	5,25 inch magnetic disk
7trackTape	006	7 track magnetic tape
9trackTape	007	9 track magnetic tape
3480Cartridge	008	3480 cartridge tape drive
3490Cartridge	009	3490 cartridge tape drive
3580Cartridge	010	3580 cartridge tape drive
4mmCartridgeTape	011	4 millimetre magnetic tape
8mmCartridgeTape	012	8 millimetre magnetic tape

Name	Domain code	Definition
1quarterInchCartridgeTape	013	0,25 inch magnetic tape
digitalLinearTape	014	half inch cartridge streaming tape drive
onLine	015	direct computer linkage
satellite	016	linkage through a satellite communication system
telephoneLink	017	communication through a telephone network
hardcopy	018	pamphlet or leaflet giving descriptive information

MD_ObligationCode (Enumeration)

Name	Domain code	Definition
MD_ObligationCode	ObCd	obligation of the element or entity
mandatory	001	element is always required
optional	002	element is not required
conditional	003	element is required when a specific condition is met

MD_PixelOrientationCode (Enumeration)

Name	Domain code	Definition
MD_PixelOrientationCode	PixOrientCd	point in a pixel corresponding to the Earth location of the pixel
center	001	point halfway between the lower left and the upper right of the pixel
lowerLeft	002	the corner in the pixel closest to the origin of the SRS; if two are at the same distance from the origin, the one with the smallest x-value
lowerRight	003	next corner counter clockwise from the lower left
upperRight	004	next corner counter clockwise from the lower right
upperLeft	005	next corner counter clockwise from the upper right

MD_ProgressCode (Code List)

Name	Domain code	Definition
MD_ProgressCode	ProgCd	status of the data set or progress of a review
Completed	001	production of the data has been completed
historicalArchive	002	data has been stored in an offline storage facility
Obsolete	003	data is no longer relevant
OnGoing	004	data is continually being updated
Planned	005	fixed date has been established upon or by which the data will be created or updated
Required	006	data needs to be generated or updated
underDevelopment	007	data is currently in the process of being created

MD_RestrictionCode (Code List)

Name	Domain code	Definition
MD_RestrictionCode	RestrictCd	limitation(s) placed upon the access or use of the data
Copyright	001	exclusive right to the publication, production, or sale of the rights to a literary, dramatic, musical, or artistic work, or to the use of a commercial print or label, granted by law for a specified period of time to an author, composer, artist, distributor
patent	002	government has granted exclusive right to make, sell, use or license an invention or discovery
patentPending	003	produced or sold information awaiting a patent
trademark	004	a name, symbol, or other device identifying a product, officially registered and legally restricted to the use of the owner or manufacturer
license	005	formal permission to do something
intellectualPropertyRights	006	rights to financial benefit from and control of distribution of non-tangible property that is a result of creativity
restricted	007	withheld from general circulation or disclosure
otherRestrictions	008	limitation not listed

MD_ScopeCode (Code List)

Name	Domain code	Definition
MD_ScopeCode	ScopeCd	class of information to which the referencing entity applies
attribute	001	information applies to the attribute class
attributeType	002	information applies to the characteristic of a feature
collectionHardware	003	information applies to the collection hardware class
collectionSession	004	information applies to the collection session
data set	005	information applies to the data set
series	006	information applies to the series
nonGeographicData set	007	information applies to non-geographic data
dimensionGroup	008	information applies to a dimension group
feature	009	information applies to a feature
featureType	010	information applies to a feature type
propertyType	011	information applies to a property type
fieldSession	012	information applies to a field session
software	013	information applies to a computer program or routine
service	014	information applies to a capability which a service provider entity makes available to a service user entity through a set of interfaces that define a behaviour, such as a use case
model	015	information applies to a copy or imitation of an existing or hypothetical object
tile	016	information applies to a tile, a spatial subset of geographic data

MD_SpatialRepresentationTypeCode (Code List)

Name	Domain code	Definition
MD_SpatialRepresentationTypeCode	SpatRepTypCd	method used to represent geographic information in the data set
vector	001	vector data is used to represent geographic data
grid	002	grid data is used to represent geographic data
textTable	003	textual or tabular data is used to represent geographic data
tin	004	triangulated irregular network
stereoModel	005	three-dimensional view formed by the intersecting homologous rays of an overlapping pair of images
video	006	Scene from a video recording

MD_TopicCategoryCode (Code List)

Name	Domain code	Definition
MD_TopicCategoryCode	TopicCatCd	high-level geographic data thematic classification to assist in the grouping and search of available geographic data sets. Can be used to group keywords as well. Listed examples are not exhaustive. NOTE It is understood there are overlaps between general categories and the user is encouraged to select the one most appropriate.
farming	001	rearing of animals and/or cultivation of plants Examples: agriculture, irrigation, aquaculture, plantations, herding, pests and diseases affecting crops and livestock
biota	002	flora and/or fauna in natural environment Examples: wildlife, vegetation, biological sciences, ecology, wilderness, sealife, wetlands, habitat

Name	Domain code	Definition
boundaries	003	legal land descriptions Examples: political and administrative boundaries
climatologyMeteorologyAtmosphere	004	processes and phenomena of the atmosphere Examples: cloud cover, weather, climate, atmospheric conditions, climate change, precipitation
economy	005	economic activities, conditions and employment Examples: production, labour, revenue, commerce, industry, tourism and ecotourism, forestry, fisheries, commercial or subsistence hunting, exploration and exploitation of resources such as minerals, oil and gas
elevation	006	height above or below sea level Examples: altitude, bathymetry, digital elevation models, slope, derived products
environment	007	environmental resources, protection and conservation Examples: environmental pollution, waste storage and treatment, environmental impact assessment, monitoring environmental risk, nature reserves, landscape
geoscientificInformation	008	information pertaining to earth sciences Examples: geophysical features and processes, geology, minerals, sciences dealing with the composition, structure and origin of the earth's rocks, risks of earthquakes, volcanic activity, landslides, gravity information, soils, permafrost, hydrogeology, erosion
health	009	health, health services, human ecology, and safety Examples: disease and illness, factors affecting health, hygiene, substance abuse, mental and physical health, health services

Name	Domain code	Definition
imageryBaseMapsEarthCover	010	base maps Examples: land cover, topographic maps, imagery, unclassified images, annotations
intelligenceMilitary	011	military bases, structures, activities Examples: barracks, training grounds, military transportation, information collection
inlandWaters	012	inland water features, drainage systems and their characteristics Examples: rivers and glaciers, salt lakes, water utilization plans, dams, currents, floods, water quality, hydrographic charts
location	013	positional information and services Examples: addresses, geodetic networks, control points, postal zones and services, place names
oceans	014	features and characteristics of salt water bodies (excluding inland waters) Examples: tides, tidal waves, coastal information, reefs
planningCadastre	015	information used for appropriate actions for future use of the land Examples: land use maps, zoning maps, cadastral surveys, land ownership
society	016	characteristics of society and cultures Examples: settlements, anthropology, archaeology, education, traditional beliefs, manners and customs, demographic data, recreational areas and activities, social impact assessments, crime and justice, census information
structure	017	man-made construction Examples: buildings, museums, churches, factories, housing, monuments, shops, towers

Name	Domain code	Definition
transportation	018	means and aids for conveying persons and/or goods Examples: roads, airports/airstrips, shipping routes, tunnels, nautical charts, vehicle or vessel location, aeronautical charts, railways
utilitiesCommunication	019	energy, water and waste systems and communications infrastructure and services Examples: hydroelectricity, geothermal, solar and nuclear sources of energy, water purification and distribution, sewage collection and disposal, electricity and gas distribution, data communication, telecommunication, radio, communication networks
aviationObstacles	020	All fixed (whether temporary or permanent) and mobile objects, or parts thereof, that are located on an area intended for the surface movement of aircraft or that extend above a defined surface intended to protect aircraft in flight. Note. This code has been added to the ISO code list for the purposes of this interchange standard.
aerodromeMap	021	Aerodrome mapping database Note. This code has been added to the ISO code list for the purposes of this interchange standard.

MD_TopologyLevelCode (Code List)

Name	Domain code	Definition
MD_TopologyLevelCode	TopoLevCd	degree of complexity of the spatial relationships
geometryOnly	001	geometry objects without any additional structure which describes topology
topology1D	002	1-dimensional topological complex – commonly called “chain-node” topology
planarGraph	003	1-dimensional topological complex that is planar. (A planar graph is a graph that can be drawn in a plane in such a way that no two edges intersect except at a vertex.)
fullPlanarGraph	004	2-dimensional topological complex that is planar. (A 2-dimensional topological complex is commonly called “full topology” in a cartographic 2D environment.)
surfaceGraph	005	1-dimensional topological complex that is isomorphic to a subset of a surface. (A geometric complex is isomorphic to a topological complex if their elements are in a one-to-one, dimensional-and boundary-preserving correspondence to one another.)
fullSurfaceGraph	006	2-dimensional topological complex that is isomorphic to a subset of a surface
topology3D	007	3-dimensional topological complex. (A topological complex is a collection of topological primitives that are closed under the boundary operations.)
fullTopology3D	008	complete coverage of a 3D Euclidean coordinate space
abstract	009	topological complex without any specified geometric realization

Definition of a new metadata code list

An existing metadata element is suitable, given that the “free text” domain of the identified element is restricted. No existing metadata code list can be identified within the metadata standard that meets the requirements. In this circumstance a new metadata code list may be defined to meet the specific requirements of the profile.

The new metadata code list should be defined in a style consistent with that of ISO 19115 (which is based on ISO/IEC 11179-3). Method:

1. Define the new metadata code list in terms of Definition (B.1.4), Name (B.1.2), and Short Name (B.1.3). The definition of the new code list should be done so as to be consistent with the existing code lists that can be found in clause B.5 of ISO 19115.
2. Define the new metadata code list elements in terms of Definition (B.1.4) and Domain code and Short Name (B.1.3). This definition should also be done so as to be consistent with the existing code list elements found in clause B.5 of ISO 19115.

Definition of a new metadata code list element

An existing metadata element is suitable, given that the metadata code list of the identified element is expanded. The new metadata code list elements should be defined with reference to the existing set of elements. The expanded metadata code list must be a logical expansion of the standard set of values.

If the proposed new metadata domain element does not logically build upon the original domain then it may be that the identified element is not suitable for expansion.

Additional ISO references for code lists

ISO 639 (all parts), *Codes for the representation of names of languages*

ISO 3166 (all parts), *Codes for the representation of names of countries and their subdivisions*

ISO 4217:1995, *Codes for the representation of currencies and funds*

ISO 8859 (parts 1 to 15), *Information technology — 8 bit single byte coded graphic character sets*

ISO/IEC-10646-1, *Information technology — Universal Multiple-Octet Coded Character Set (UCS) — Part 1: Architecture and Basic Multilingual Plane*

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