



**Cuestión 5 del
Orden del Día**

**Revisión de otros asuntos técnicos
5.2 Cartografía de aeródromos basada en el e-TOD**

DATOS ELECTRÓNICOS SOBRE EL TERRENO Y OBSTÁCULOS

(Presentada por la Secretaría)

RESUMEN

La siguiente nota de estudio se refiere al requerimiento del Anexo 14 sobre la medición de las coordenadas geográficas de los obstáculos y su notificación a los servicios de información aeronáutica (AIP) y la aplicación de la disposición 10.6.1.2 del Anexo 15 relativa a la disponibilidad, al 18 de noviembre de 2010, de datos sobre obstáculos conforme a las especificaciones del Área 2 y del Área 3 la misma que se facilitaría mediante la planificación avanzada y apropiada de la recolección y el procesamiento de esos datos.

Asimismo, se describen los beneficios asociados con la implementación de la cartografía de aeródromo con información basada en el e-TOD.

Referencias:

- Anexo 4 — *Cartas Aeronáuticas*
- Anexo 6 — *Operación de Aeronaves, Parte I — Transporte Aéreo Comercial Internacional — Aeronaves*
- Anexo 11 — *Servicios de Tránsito Aéreo*
- Anexo 14 — *Aeródromos, Volumen I — Diseño y Operaciones de Aeródromos, Volumen II — Helipuertos*
- Anexo 15 — *Servicios de Información Aeronáutica*
- Doc. 8168 — *Procedimientos para los Servicios de Navegación Aérea — Operaciones (PANS-OPS)*
- Doc. 8126 — *Manual de Servicios de Información Aeronáutica*
- Doc. 8697 — *Manual de Cartas Aeronáuticas.*
- Doc. 9674 — *Manual del Sistema Geodésico Mundial — 1984 (WGS-84)*
- Doc. 9881, *Guidelines for Electronic Terrain, Obstacle and Aerodrome Mapping Information.*

**Objetivos
Estratégicos**

Esta nota de estudio se relaciona con el Objetivo estratégico D.

1. Introducción

1.1 Se puede identificar en los aeródromos de gran tamaño, las diversas actividades que realizan un gran número de participantes como los pilotos, personal de operaciones de las líneas aéreas, personal de operaciones de la aviación general, controladores de tránsito aéreo, controladores en rampa, operadores de vehículos en tierra, personal de construcción / mantenimiento, personal de emergencia / seguridad, etc. Todos los participantes involucrados deben colaborar estrechamente para asegurar la seguridad operacional y eficiencia de las operaciones aéreas en el aeródromo y por este motivo deben conocer el plan general del aeródromo.

1.2 El reporte de las coordenadas geográficas de los obstáculos deben realizarse de acuerdo a los requisitos de calidad de la información aeronáutica prescrito para las características de diseño del aeródromo en particular y su presentación a la repartición del Estado encargada de la Publicación de Información Aeronáutica.

1.3 Se proveerán beneficios significativos a la seguridad operacional de la aviación civil internacional por las aplicaciones basadas en vuelo y tierra que se apoyan en la calidad de información electrónica del terreno y los obstáculos. El incremento a nivel mundial del conjunto de equipos para aeronaves y las unidades de control de tránsito aéreo con sistemas que se utilizan para la información electrónica del terreno, requieren de una normalización en la provisión de información de apoyo. Más aún, como la información sobre el terreno se está incrementando como uso primario en las tripulaciones, otro personal involucrado en las operaciones también se beneficiará del uso de la calidad de información sobre el terreno y los obstáculos.

1.4 Las nuevas previsiones del Anexo 15 se relacionan con el propósito que cumple la información electrónica sobre el terreno y los obstáculos, su cobertura, requerimientos numéricos de los obstáculos y el terreno, contenido y estructura del terreno y base de datos de los obstáculos, especificaciones sobre el producto de la información para el terreno y los obstáculos y la disponibilidad para su uso. En adición, las aplicaciones para las cuales la calidad de información sobre el terreno y los obstáculos, utilizados en conjunto con la información aeronáutica requerida ha sido también identificada.

2. Datos electrónicos sobre el terreno y obstáculos

2.1 Para satisfacer los requisitos de los usuarios necesarios sobre datos electrónicos sobre el terreno y Obstáculos, considerando el costo – beneficio, métodos de adquisición e información disponible, dicha información debe proveerse de acuerdo a cuatro áreas básicas de cobertura:

- Área 1: todo el territorio de un Estado;
- Área 2: Área de control terminal;
- Área 3: Área del aeródromo/helipuerto; y
- Área 4: Área de operaciones Categoría II o III.

2.2 El Área 1 tiene una cobertura total del territorio de un Estado, incluyendo aeródromos/helipuertos. El Área 2 cubre el control de las áreas terminales establecidas, que no exceda un radio de 45 Km del punto de referencia del aeródromo (ARP); que coincida con la especificación actual para la provisión de información topográfica en la Carta de Obstáculos de Aeródromo – Tipo C de OACI (Anexo 14, párrafo 5.3.1 c) referencia). El Área 3 cubre el área que se encuentra en las distancias especificadas de los bordes de un aeródromo definido o superficie del área de movimiento de un helipuerto mientras que el Área 4 está limitada a las pistas en que se han establecido operaciones de aproximación de precisión de Categoría II ó III, en la que se necesita información detallada sobre el terreno por parte de los operadores para permitirles evaluar el efecto del terreno al determinar la altura de decisión con radio altímetro.

2.3 **Base de datos sobre el terreno — Contenido y estructura.** Una base de datos sobre el terreno tendrá conjuntos de datos digitales que representen la superficie del terreno en forma de valores de elevación continuos en todas las intersecciones (puntos) de una retícula definida, en relación con referencias comunes. Una retícula sobre el terreno será angular o lineal y tendrá forma regular o irregular. Los conjuntos de datos electrónicos sobre el terreno incluirán aspectos espaciales (posición y elevación), temáticos y temporales para la superficie de la Tierra en la que figuren características naturales existentes como montañas, colinas, sierras, valles, masas de agua y hielos y nieves eternos, y sin incluir los obstáculos. En términos prácticos, y dependiendo del método de adquisición que se utilice, representará la superficie continua que existe entre el suelo desnudo y la cumbre de la cubierta de copas (o un punto intermedio, conocido también como “primera superficie reflejante”).

2.4 **Base de datos sobre obstáculos — Contenido y estructura.** Una base de datos sobre obstáculos contendrá un conjunto de datos digitales sobre obstáculos e incluirá las características cuya dimensión vertical tenga importancia en relación con las características contiguas y cercanas que se consideren peligrosas para la navegación aérea. Los datos sobre obstáculos abarcarán la representación digital de la extensión vertical y horizontal de los objetos artificiales. Los obstáculos no se incluirán en las bases de datos sobre el terreno. Los elementos de datos sobre obstáculos son características que se representarán en las bases de datos por puntos, líneas o polígonos.

2.5 **Especificaciones de productos de datos sobre el terreno y los obstáculos.** Para permitir y apoyar el intercambio y utilización de conjuntos de datos electrónicos sobre el terreno y los obstáculos entre diferentes proveedores de datos y usuarios de datos, se utilizarán la serie ISO 19110 de las normas para información geográfica como marco de modelos de datos en general.

2.6 Cada especificación de producto de datos sobre el terreno incluirá una reseña, el alcance de la especificación, identificación del producto de datos, contenido y estructura de los datos, sistema de referencia, calidad de los datos, captura de datos, mantenimiento de los datos, representación de los datos, distribución del producto de datos, información suplementaria y metadatos. La especificación de datos sobre el terreno debe incluir información sobre el estado de captura de información el cual deberá ser una descripción general de las fuentes y de los procesos aplicados para la captura de la información del terreno. Los principios y criterios aplicados en el mantenimiento de la información del terreno y de los obstáculos, deberán proveerse con las especificaciones de información, incluyendo la frecuencia con la cual la información ha sido actualizada.

2.7 Disponibilidad. Los Estados garantizarán que a partir del 18 de Noviembre de 2010, los datos electrónicos sobre el terreno y sobre obstáculos se ponen a disposición de conformidad con las especificaciones correspondientes a las áreas 2 y 3.

3. Información cartográfica de Aeródromo

3.1 El Documento 9881- “*Guidelines for Electronic Terrain, Obstacle and Aerodrome Mapping Information*”, provee una guía completa para la información cartográfica de superficie del aeródromo requerida por los usuarios aeronáuticos y particularmente para uso en vuelo de las aeronaves. En la guía se incluyen los requerimientos mínimos y material de referencia para el contenido, origen, publicación, mantenimiento y mejoras de la información cartográfica de aeródromo. Asimismo, provee un enfoque integral con relación a la información cartográfica de aeródromo disponible en forma de información resultante específica. Esta especificación tiene por objetivo el uso por los usuarios cuando evalúan los resultados y determinan si los requerimientos satisfacen las aplicaciones particulares para su uso.

3.2 Información sobre el terreno en el Área Terminal. Consideraciones sobre el terreno en y los alrededores del aeródromo es esencial a las operaciones en el espacio aéreo del área terminal tales como aproximación, despegue, y procedimientos de planeación en contingencias. Los peligros asociados con el terreno del área terminal, los riesgos que implica y las acciones para evitarlos son citados como un factor contribuyente del control de vuelo en los accidentes en el terreno (CFIT). El terreno es también importante para la navegación en superficie. Define la superficie topográfica del terreno en y alrededor de las superficies del área de movimiento. Como la información sobre el terreno incluye a otros objetos geométricos en la superficie de los aeródromos (pistas, calles de rodaje, edificios, etc.), es importante que la información sobre el terreno esté correlacionada con este otro tipo de información.

3.3 **Concepto operacional – Gestión de las Facilidades del Aeródromo.** Existen seis categorías de actividades principales que se incluyen en el objetivo de la gestión de las facilidades de aeródromo:

- Planeación
- Diseño de Aeródromo
- Diseño de las Facilidades
- Construcción
- Medio ambiente
- Administración

3.4 Cada una de estas actividades puede beneficiarse de la información disponible sobre la cartografía de aeródromo. Para asegurar la consistencia en las aplicaciones, una estructura de base de datos GIS con información adecuada puede ser utilizada. La implementación en cada aeródromo es exclusiva. Se prevé que la reposición primaria de la base de datos será en la forma de un centro de control operacional de aeródromo. Las reposiciones secundarias, con funcionalidad completa, podrían ser ubicadas en los centros de control de mantenimiento, centros de ingeniería de aeropuertos, y centros de control del área de movimiento del aeródromo.

3.5 Los beneficios para la gestión de las facilidades de aeródromo están categorizadas como sigue:

- Reducción en la carga de trabajo del personal para su análisis,
- Rápidas respuestas a las preguntas,
- Habilidad para manejar situaciones complejas,
- Habilidad para proveer mejor información en la toma de decisiones,
- Reducción en el gasto para el desarrollo de aplicaciones,

- Creación de un marco de trabajo básico para administrar la información geoespacial.

3.6 Otro beneficio de esta base de datos es su capacidad de retener la información espacial inicial. Por ejemplo, la información puede ser visualizada como en el mundo real y por lo tanto, puede crear un lenguaje común para el uso de la organización del aeródromo.

4. Conclusiones

4.1 Se invita a la Reunión a:

- a) tomar nota de la información proporcionada en esta nota de estudio;
- b) revisar la información contenida en el Apéndice a esta nota de estudio sobre datos electrónicos sobre el terreno, obstáculos e información cartografía de aeródromo, extraído del documento 9881; y
- c) se insta a los Estados y Territorios a proceder a la medición y el respectivo reporte al AIP de las coordenadas geográficas de los obstáculos en las áreas 2 y 3, de acuerdo a lo exigido en el Anexo 14.

APPENDIX / APÉNDICE

(Available only in English / Disponible únicamente en inglés)

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.

Document 9881-Guidelines for Electronic Terrain, Obstacle and Aerodrome Mapping Information, provides a complete guidance for the aerodrome surface mapping information required for aeronautical users and particularly for on-board aircraft use. The guidance included 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.

- The information contained in this document has been compiled for the purpose of stating aerodrome surface mapping information requirements for aeronautical uses, particularly on-board aircraft. The requirements are not all-inclusive, but represent those of more immediate concern. As future applications are developed, more stringent numerical requirements may be needed. Airworthiness authorities, civil aviation authorities, and the aviation industry urge the aerodrome mapping data originators and integrators to use this information when providing those data to system designers and users.
- Based on the availability of standardized aerodrome mapping databases (AMDBs), a wide variety of applications can be envisioned. It is important to note that multiple user classes can benefit from using these databases, for example: pilots, controllers, aerodrome managers, and aerodrome emergency/security personnel.
- Applications of AMDBs
 - ❖ Chart information
 - ❖ Surveillance and runway incursion detection and alerting
 - ❖ Route and hold-short display and deviation detection and alerting
 - ❖ Display of digital ATIS information
 - ❖ Aerodrome surface guidance and navigation
 - ❖ Runway operations
 - ❖ Aerodrome and airline resource management
 - ❖ Training (flight simulation)
 - ❖ Aerodrome facility and asset management
 - ❖ Emergency and security service management
 - ❖ Notice To Airmen (NOTAM) and aeronautical data overlays
 - ❖ Synthetic vision

The figure depicts the data integration processes that contribute to the development of an AMDB. Initially, data originators may collect aerodrome mapping data using various technologies (e.g. aerial photography, satellite imagery, or topographical surveys). The originators may collect data to support non-aeronautical applications; however, any data to be used to support aeronautical applications must meet the requirements defined herein (illustrated as Requirements A, in Figure 4-1).

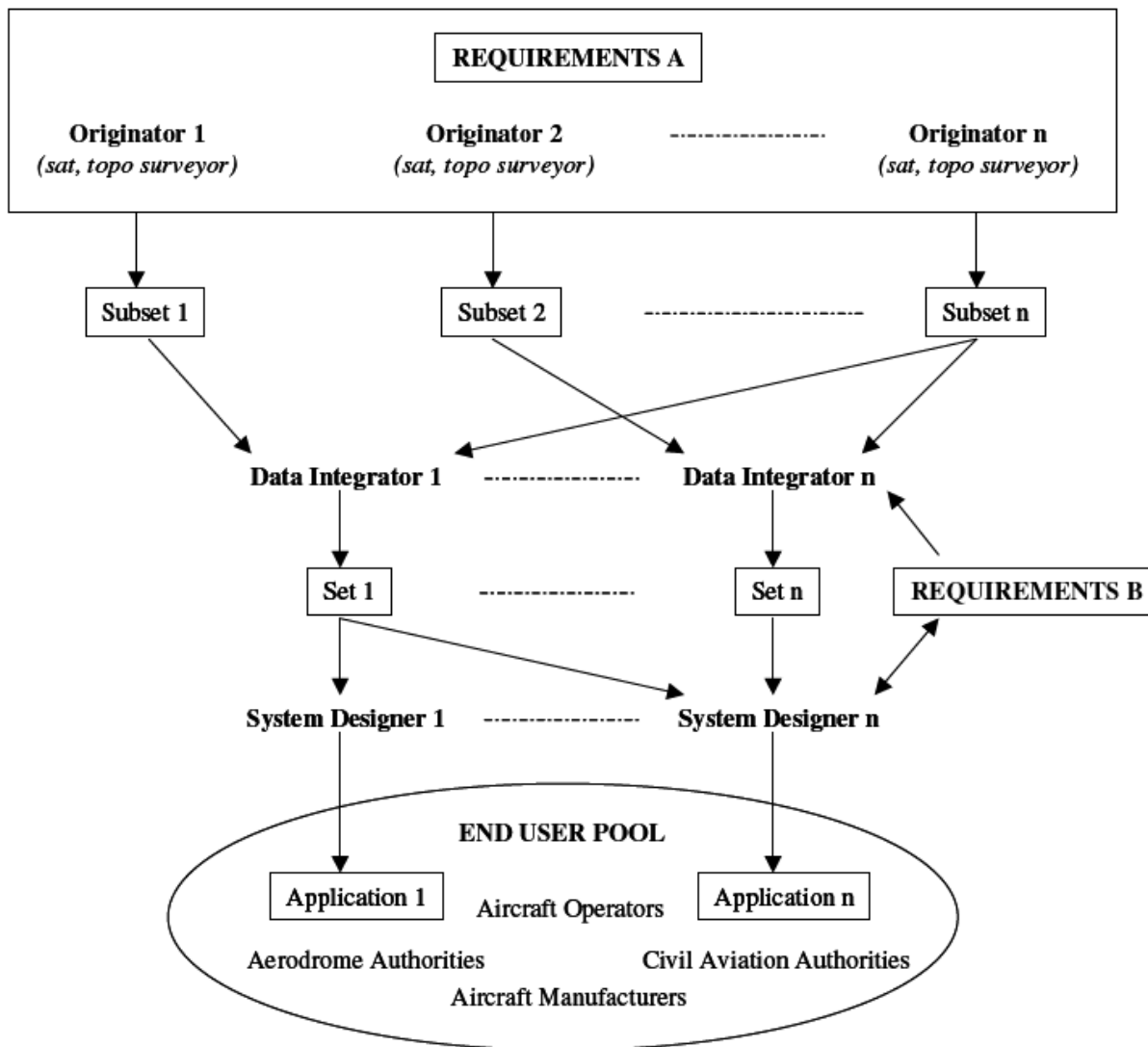


Figure 4-1. Data integration processes

When using data provided from multiple data originators, data integrator(s) may be responsible for merging all appropriate data sets for two purposes:

- ❖ the correlation of multiple data sets representing the same aerodrome area to ensure full aerodrome coverage and to ensure the required accuracy and integrity
- ❖ the concatenation of the many aerodromes into a consistent, globally-referenced database that may also include other data types such as terrain, obstacles, and/or air navigation data

Aerodrome Mapping Information

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.)

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

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)

Aerodrome Mapping Data Considerations

Different datums and sufficient conversion algorithms do not exist. Air navigation considerations and the state of the art regarding the use of the Global Navigation Satellite System (GNSS) for instantaneous positioning and navigation require that the reference frame for AMDBs be based on the theoretical surface and universally-positioned ellipsoid defined as WGS-84 (see Section 4.2). 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 gravity model.

- From an interoperability standpoint, having the data available using a common datum is essential.
- Problems may be encountered when dealing with sources that have an unknown datum.
- Further, on-board sensors and avionics instruments may provide dynamic inputs to aerodrome mapping databases. These are other sources of information that may need to be converted within the system. It is expected that these datums will be known and the appropriate conversion can be applied.
- In cases where an AMDB already exists and is based on a different reference system, the data must be transformed to a WGS-84 reference. This transformation may induce errors. Therefore, care must be taken to ensure that the conversion process does not impact the integrity of the data and prevent its use in the application for which it was intended.

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

The use of vector-based data has several advantages:

- ❖ Small data storage requirement
- ❖ Easy use of a relational data base structure
- ❖ Easier for updating purposes
- ❖ 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 approach 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, and not elevation.

Obstacle Data for the Aerodrome Surface

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 radius specified, unrealistically large, converging or overlapping buffers may be generated, resulting in high false alarm conditions. Internationally recognized survey standards should be used. Annex 14 defines the requirements for identifying aerodrome obstacle limitation surfaces. Further criteria for evaluating obstacles are contained in the *Procedures for Air Navigation Services — Aircraft Operations* (PANS-OPS). An equivalent approach to those mentioned above has been taken when considering which aerodrome obstacles should be included in AMDBs.

Terminal 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) accidents. Terrain is also important to surface navigation. 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.

General Requirements

The horizontal reference for all position data must be the WGS-84 ellipsoid. All aerodrome mapping data that includes horizontal position information must be described in units of latitude/longitude for the purpose of data interchange. It is expected that for many applications, implementation may include conversion to a local coordinate system (e.g. Cartesian) along with at least one geodetic reference point. Data quality must be preserved when performing coordinate system conversion. For all aerodrome mapping data that requires 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). The metric system must be used for all linear measurements (e.g., runway length).

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 digitizing existing charts.

A description of the process used to acquire aerodrome mapping data must be provided. This must be consistent with this document.

Data Merging

In order to maintain 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).

Data Conversion

Data sets may be converted to WGS-84 latitude/longitude (horizontal) and orthometric height (vertical); however, the original data, prior to conversion, must meet the quality standards described in this document.

Vertical Objects

Requirements regarding the collection of vertical objects are given in Annex 15 through terrain/obstacle data collection surfaces.

When surveying vertical objects, the horizontal spatial extent to be surveyed must include the aerodrome surface movement area plus a buffer of 50 meters (Figures 4-3 and 4-4), or the minimum separation distances specified in Doc 9157, whichever is greater.

When surveying vertical objects 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 centerline(s).

All vertical objects and 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 (Figure 4-4).

Control towers must always be captured regardless of the location on the aerodrome.

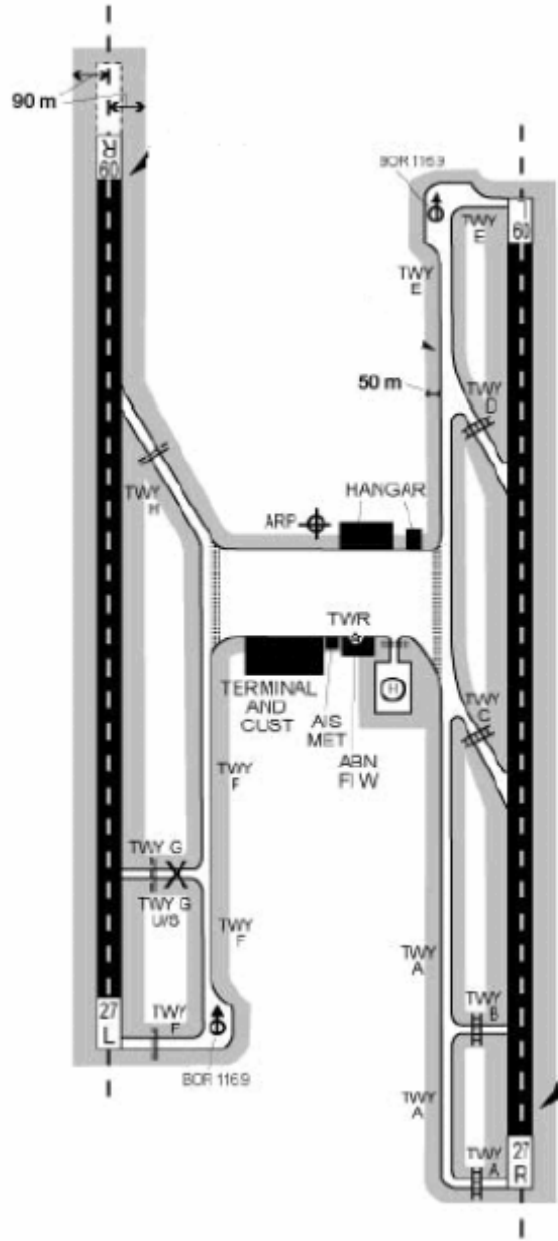


Figure 4-3. Aerodrome Mapping Data Horizontal Extent

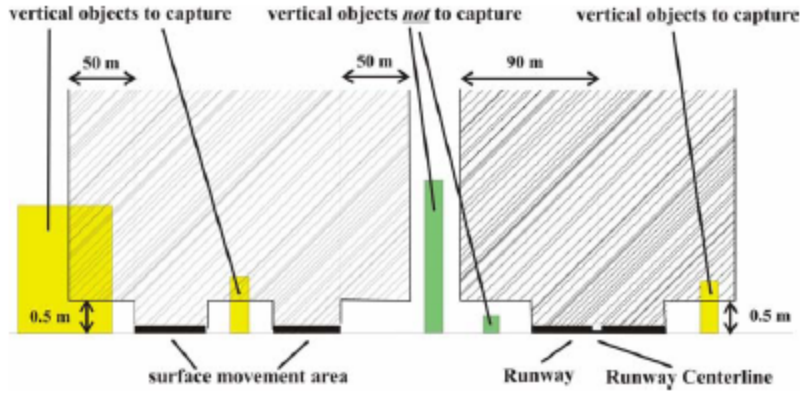


Figure 4-4. Aerodrome Mapping Data Vertical Extent

Data Elements

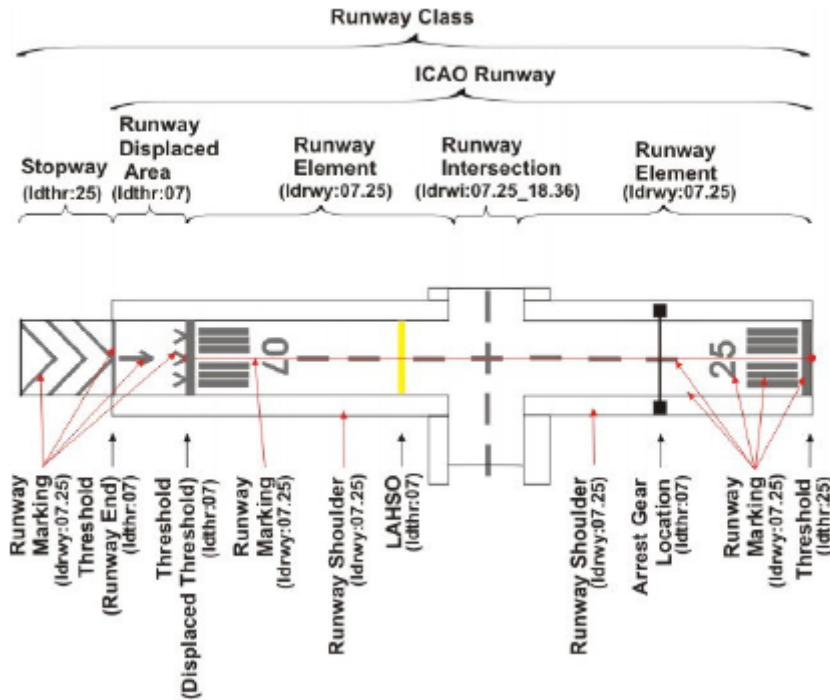
For the purposes of this document, data elements have been listed by class. The seven classes are runways, helipads, taxiways, aprons, vertical structures, construction areas, and quality data. Each class requires that different objects be captured in the AMDB.

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 the rules of the feature catalogue.

Runways

An overview of runway data elements is shown in the following **Figure 4-11. Runway Elements:**



Aprons

The Apron as defined in Annex 14, Volume I, paragraph 1.1 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 4-19.

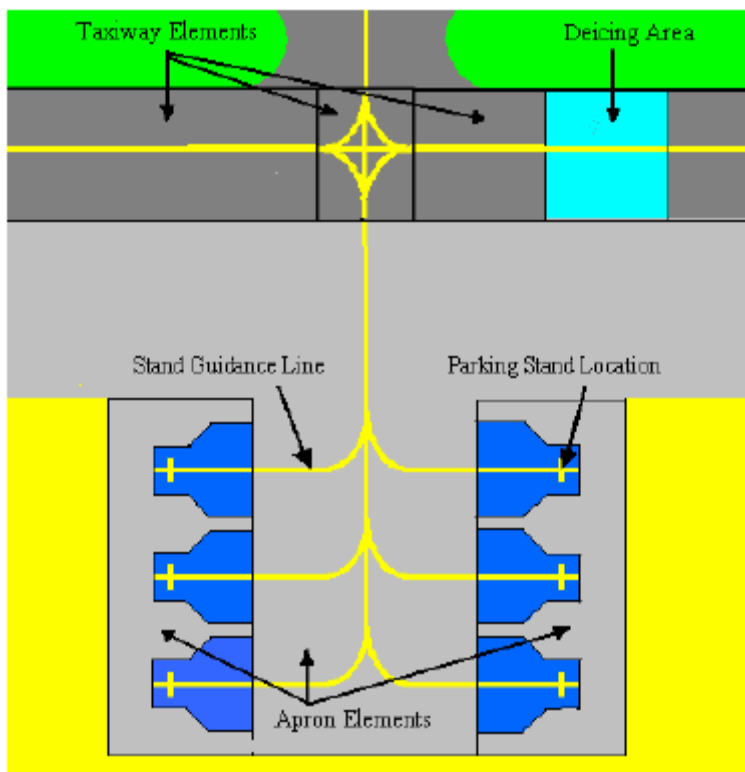


Figure 4-19. Aprons

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

**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.

Surveillance and Conflict (Runway Incursion) Detection and Alerting Operational Concept

In today's operations, flight crews maintain traffic awareness on the surface by way of frequent visual scans and, in some cases, radio communications with ATC to obtain traffic advisories. Except for a few rare runway/taxiway geometries (obtuse-angled intersections) and high-workload situations, this method of surveillance is adequate during VMC. However, as weather conditions deteriorate (i.e., IMC), at night, or under high workload conditions, maintaining awareness of traffic on the aerodrome surfaces can become increasingly difficult. In these types of situations, uncertainties can arise that, in the best case, reduce traffic flow rates, and in the worst case, increase the likelihood of a runway incursion and/or surface accident.

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 Aerodrome

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 communications¹⁴. This increased awareness can:

- ❖ 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

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.

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.

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

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

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.

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