for Information Technology—

Geographic Information Framework – Data Content Standards For Transportation Networks: Air

American National Standard
for Information Technology

Geographic Information Framework
Data Content Standards
For Transportation Networks: Air
(Part XXX)

Secretariat
INFORMATION TECHNOLOGY INDUSTRY COUNCIL
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Published by:
Information Technology Industry Council
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Foreword

The primary purpose of the standard is to support the exchange of data related to air transportation. This standard also seeks to establish a common baseline for the content of air transportation databases for public agencies and private enterprises. It seeks to decrease the costs of acquiring and exchanging aviation data for local, tribal, state, and federal users and creators of air transportation data. Benefits of adopting the standard also include the long-term improvement of the geospatial data that can be used to support capacity, safety, security, operations and maintenance procedures at airports.

This is the first edition of this standard. However, this standard was preceded by other work that has contributed to its development. These include:

- GIS Airport Layout Plan Standards developed by the Atlanta Hartsfield International Airport Department of Aviation (May 29, 2002) [1].
- User Requirements for Aerodrome Mapping Information (DO-272) [2] developed by a multinational committee of aviation experts under the auspices of RTCA and EUROCAE.
- The Federal Aviation Administration's adaptation of RTCA/EUROCAE's User Requirements for Aerodrome Mapping Information for the Safe Flight 21 Program.
- Eurocontrol's AIXM model for aviation data exchange.

In addition, the development of this standard has benefited from an FAA project to create a data standard that can support electronic Airport Layout Plans (eALP). Given the similar objectives and overlapping domains of the FAA eALP project and this effort, the models being created have essentially been merged. The result has been a single model for aviation data exchange that encompasses a more comprehensive set of user requirements. The Air Modeling Advisory Team (MAT) has pursued a strategy that ensures the Air MAT standard shall encompass in its entirety all of the elements and attributes of both of the aforementioned standards.

This standard has been developed to fulfill one of the objectives of the National Spatial Data Infrastructure (NSDI), i.e., to create common geographic base data for seven critical data themes. These core themes are considered Framework data, reflecting their critical importance as geographic infrastructure. The Geospatial One Stop initiative is an electronic government initiative of the federal government designed to expedite the creation of the seven Framework layers. This standard has been developed in response to the One Stop initiative to realize the goals and objectives of the NSDI.

Suggestions for improvements of this standard will be welcome. They should be sent to

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This standard was processed and approved for submittal to ANSI by the Accredited Standards Committee – INCITS/L1. Committee approval of this Standard does not necessarily imply that all committee members voted for its approval.

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American National Standard for Information Technology
Geographic Information Framework
Data Content Standards
(ANSI X.X.X2002)

1 Scope of this Standard

The primary purpose of the standard is to support the exchange of transportation data related to aviation, one of at least five modes that compose the transportation theme of the geospatial data framework. More specifically, the standard encompasses spatial data, as well as related attributes and metadata, which can be used to depict the most broadly used elements of the U.S. National Airspace System (NAS). The NAS is a national system of aviation infrastructure that includes over several thousand commercial, military and general aviation airports and heliports in the United States as well as thousands of FAA facilities that support air navigation over U.S. skies. While the ultimate purpose is to address all elements of the NAS to their fullest extent, this first edition focuses on elements at or related to airports at a specific point in time. Although this standard is intended to support airport map data collection and airport map data exchange, the standard should not be used to support data that is required for the navigation of aircraft on the surface or in the air, nor should it be used for data that is required for operation of the NAS.

While the impetus for this standard is from the U.S. government, it is recognized that a standard for the exchange of aviation data must be global in perspective. For this reason, efforts have been made to make this standard compatible with similar international standards. It is the ultimate intent of the standard to allow the widest utility of aviation data by enhancing data sharing and reducing redundant data production.

This standard is made up of numerous types of manmade (e.g. runways, taxiways, etc.) and natural (e.g. terrain) features that have been determined to be relevant to air transportation. Each of these features can have geographic locations and characteristics. These features can also be interconnected in various ways to represent a complete operating environment such as an airport or sub-sets of an airport such as the equipment that supports air navigation to a specific runway. Eventually, in future versions of this standard, airspace features and off-airport navigational aides will be included to support the exchange of information about airspace and air networks. It is anticipated that such future versions of this data standard will support the data sharing needs of the entire air transportation community.

This standard can be implemented using a variety of software packages and is designed to accommodate data encoded without geometry as well as to support the exchange of data encoded in a variety of geographic information systems. It is designed to be able to depict airports of all levels of service and all functional classes that may be defined by a data-providing agency. It accommodates assets associated with aviation that are typically used for navigation, safety, security, operations and maintenance.

The air standard will initially apply to National Spatial Data Infrastructure (NSDI) Framework transportation data produced or disseminated by or for the federal government. This standard is not intended to supercede the airport data collection needs and requirements of the Federal Aviation Administration. It is recognized that the Federal Aviation Administration has data quality requirements (spatial, temporal, data integrity) related to air safety that this standard does not support. According to Executive Order 12906, Coordinating Geographic Data Acquisition and Access: the National Spatial Data Infrastructure [5], federal agencies collecting or producing geospatial data, either directly or indirectly (e.g., through grants, partnerships, or contracts with other entities), shall ensure, prior to obligating funds for such activities, that data will be collected in a manner that meets all relevant standards adopted through the Federal Geographic Data Committee (FGDC) process.

It is critical to note however that this is a first version of the standard and only incorporates core geospatial features related to airports. More specifically, the following areas have been identified as critical aviation data elements that should be considered in future versions.

- The Air MAT recognizes the importance of airspace. However, the complexity of adding airspace features to the model precluded its inclusion in this version of the standard. The Evaluation Surface feature has however been included in this version to accommodate airport specific airspace features such as FAR Part 77 [6] and TERPS surfaces.

- The utilities that support airport infrastructure were also deemed too complex to adequately address in this version of the standard. However, the Air MAT recognizes that utilities are an important feature that should be included in future models.

- Temporal data, or data indicating specific periods or ranges of time, has not been incorporated into this version of the model. Lack of this type of information limits the ability of the model, in its current form, to fully address the needs of such a dynamic environment as an airport or the entire NAS. While temporal data is not addressed to the extent that will ultimately be required, the metadata elements of the model do allow the date(s) of applicability of information currently in the model to be tracked.

The areas listed above and others will be critical additions to future versions of this standard. Prior to that time, the data elements currently captured in the standard are not in and of themselves sufficient for air navigation or the operation of airports or the NAS. This being said, the model can be used to exchange information to users and for uses that do not require more detailed airspace, utilities and temporal data. Prior to future revisions to this standard, users who do require these details can build upon the current structures of the standard to accommodate their needs. The advantage of this approach is the ability to begin the exchange of some data elements and the use of their additions to support future model enhancements. Ultimately, it is the responsibility of the user and developer of any system, whether it is based on this standard or not, to ensure that the data meets their specific requirements.

In order to address the completeness of the standard, the Air MAT anticipates further discussion to accommodate airspace, airport utilities, airport security features, airport terminal facility features, airspace features, off-airport navigational aids, temporal data and other elements deemed important to air transportation. Recommendations will be incorporated into this standard where applicable.

1.1 Harmonization with other Aviation Data Content Standards

Early in the process of developing the Air MAT standard, committee members recognized that much, if not all, aviation data elements are already modeled in one or more existing aviation data standards. This being the case, a more valuable accomplishment is to review existing models and adapt what they collectively provide to meet the Air MAT's requirements. In doing so, care was taken and compromises were made to adhere to the requirements of the originating standard as well. This was done as a means to support compatibility between the standards and therefore broader exchange of information. This process, called harmonization, was or will be carried out on the following existing data standards.

1.1.1 Coordination with FAA eALP Project

The FAA requires all airports that receive federal funding to submit and update an Airport Layout Plan (ALP). These ALPs serve as a general airport basemap intended for planning purposes. Over time, ALPs have become popular for a variety of other purposes as including airport engineering, operations, and maintenance. The data standards and procedures currently used to create ALPs were not designed with modern spatial technology in mind. As a result most airports submit ALPs in paper format, which the FAA stores in file rooms throughout the country.

The FAA sees benefit in moving ALPs from a paper based to an electronic format. Such a strategy has the potential to create a rich, national data set of airport features that can be used by several divisions of the FAA, as well as airports and other key stakeholders. To accomplish this goal the FAA initiated in November 2002 an eALP project which will design, build and implement a national ALP repository as well as the procedures and tools by which airports will submit data and extract useful information. The early phases of this project have focused on identifying relevant data elements, requirements for these elements and relationships between them.

Considerable effort has been expended to coordinate the FAA eALP effort with the efforts of the Air MAT. The result is a combined model that satisfies a broader set of user interests. Some of the most critical benefits of coordinating the FAA eALP model with the Air MAT model are listed below:

- The individuals and agencies that create spatial data for aviation, namely FAA, NOAA/NGS, airports, consultants and private sector data providers will be better able to supply data to the FAA and the aviation community via the Geospatial One Stop if the data is organized based on a common standard.

- Consistency is a major component of spatial data quality. By bringing these efforts together, redundancy in airport data and airport data collection efforts will be minimized and data consistency will be maximized.

- Private industry is more apt to develop solutions that make use of, and build upon the eALP and Air MAT models if they are consistent.

- Should the FAA require data from airports throughout the nation based on a consistent standard, a broad, rich set of airport data will very quickly become available to other potential users via the Geospatial One Stop.

- The FAA eALP project can benefit from the funding, resources, and development being dedicated to the Geospatial One Stop. Conversely, the Geospatial One Stop can benefit from the support and expertise of the FAA, the agency responsible for regulating and operating our national airspace system.

- The Air MAT committee includes members from the FAA, airports, the National Imagery and Mapping Agency (NIMA), the US Army Corps of Engineers CADD/GIS Technology Center, AAAE GIS Standards Subcommittee and private industry. The eALP project team includes members from several divisions of the FAA, NOAA/NGS and contractors with private industry and airport experience. Together these groups of professionals offer broader expertise than either group alone.

- The Air MAT recognizes that airport terminal facility features and security features have grown to become as critical as airfield features. These include AOA access doors and gates, fences, security checkpoints, passenger and baggage scanning.

1.1.2 Coordination with DO-272 and DO-276 [7]

In 2000, a international committee of aviation experts were formed under RTCA, Inc. to assess and document “User Requirements for Aerodrome Mapping Information” and “User Requirements for Obstacle and Terrain Data”. This resulted in two documents, RTCA DO-276 [6] and DO-272, respectively. Together these documents are a major accomplishment in the worldwide standardization of data depicting airside infrastructure of an airport, as well as obstacle and terrain data. Since being published, they have gained broad support and developed a wide international user base.

Because of these achievements, the Air MAT considered each element of DO-272 and DO-276 and determined that they adequately met the exchange objectives of the Geospatial One Stop. Based on this determination, all features contained in DO-272 and DO-276 have been incorporated into the Air MAT data standard. These features have also been defined the same in both standards, with some clarifications necessary to make them compatible with existing FAA definitions. Note, that the initial version of the Air MAT does not include all attributes in DO-272 and DO-276, but future versions will review these as well. In the meantime, users that require this attribute information can incorporate them as necessary.

1.1.3 Future Coordination with ANSI INCITS 353 SDSFIE [8]

For over a decade, the U.S. CADD/GIS Technology Center (formerly the Tri-Services CADD/GIS Technology Center) has produced the Spatial Data Standard for Facilities Infrastructure and the Environment (SDSFIE). Many military and a growing number of civilian airports as well as the American Association of Airport Executives GIS Standards Sub-

Committee have endorsed this standard for structuring geospatial data for airports. It is widely recognized, however, that this standard does not fully address the needs of a commercial airport. To remedy this, members of the Air MAT committee recommend a future effort to harmonize the Air MAT, eALP and DO-272/276 data structures with aviation data elements contained within the SDSFIE.

1.1.4 Future Coordination with AIXM

The Aviation Information eXchange Model (AIXM) was developed by European aviation experts. It includes airport, navigational aid and airspace features, their relationships to one another and relevant attributes. It has been is existence for several years and has undergone 3 major and several minor version enhancements.

In its current form, AIXM in many ways represents what the Air MAT model may resemble in the future. One noticeable difference is that AIXM does not currently include the spatial content which the Air MAT was established to address. This is not a major difference, however, since both models capture critical components of aviation infrastructure and their relationships to one another. The broader coverage of features and rich attribute information in AIXM and the spatial content of the Air MAT model, in fact are compatible and valuable compliments to one-another.

Recognizing this, members of the Air MAT reviewed AIXM and determined that it covers most if not all of the data elements contained in the Air MAT and much more. Because of its broader coverage and therefore complexity and due to differences between European and U.S. terminology, it was determined that AIXM could not be accepted wholesale. Instead, a feature by feature comparison and harmonization effort is recommended. Such an effort fell outside of the scope of the Air MAT's activities although AIXM was used as a reference.

Based on the similarities between the Air MAT and AIXM objectives and their mutually complimentary content, a more thorough harmonization process is recommended. Such an effort will not only benefit future versions of both standards, but more importantly lead to easier international exchange of aviation data.

2 Normative References

The following standards contain provisions, which through reference in this text constitute provisions of this American National Standard. Other standards applicable to this document are referenced in the ANSI Base Transportation Standard [9]. Users are advised to refer to that document for a complete list of normative references. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this American National Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below.

[1] Atlanta Hartsfield International Airport, Department of Aviation. *GIS Airport Layout Plan Standards*, unpublished draft, 29 May 2002.

[2] RTCA, October 12, 2001, *User Requirements for Aerodrome Mapping Information*, DO-272, prepared by RTCA Special Committee 193 and EUROCAE Working Group 44.

[3] Federal Aviation Administration, *Safe Flight 21 Program, adaptation of RTCA/EUROCAE's User Requirements for Aerodrome Mapping Information*.

[4] Eurocontrol/Aeronautical Information Services, *Aeronautical Information Conceptual Model (AICM)/ Aeronautical Information Exchange Model (AIXM),* V3.3.

[5] Executive Order 12906, Federal Register, Vol. 59, No. 71, 1994.

[6] FAR/AIM, 2002, *Federal Aviation Regulations, Aeronautical Information Manual.*

[7] RTCA, DO-276, *User Requirements for Terrain and Obstacle Data*, prepared by RTCA Special Committee 193 and EUROCAE Working Group 44.

[8] U.S. CADD/GIS Technology Center, *Spatial Data Standards for Facilities, Infrastructure and the Environment*, V2.2.

[9] American National Standards Institute, 2003, *Geospatial One Stop Base Transportation Standard.* ANSI X.X.X2002, Part XXXX.

[10] ISO 19107, *Geographic Information—Spatial Schema*.

[11] ISO 19103 – *Geographic Information: Conceptual Schema Language*

[12] ISO 19115 – *Geographic Information: Metadata*

3 Definitions

Definitions applicable to the air standard are listed here. Other, more general transportation terms are defined in the GOS Base Transportation Standard. Users are advised to consult that document for a complete set of transportation definitions. This section is subdivided in two parts containing definitions developed by the Air Modeling Advisory Team (MAT) and definitions used by the FAA Safe Flight 21 program.

3.1 Air MAT Definitions

Definitions listed below are defined and accepted by the Air MAT.

Airport – An area on land or water including any buildings or facilities intended to be used wholly or in part for the arrival or departure and surface movement of aircraft

Aircraft non-movement area - Part of an apron, and defined as pavement areas that are painted green, or pavement that has decayed, even though it appears suitable for aircraft movement.

Airport Layout Plan (ALP) – A representation of existing and proposed facilities and features necessary for the operation and development of an airport.

Airport parcel - Units of property owned by the airport authority.

Distance expression - In a position expression, the linear distance measured along a linear element.

Feature event – (TRN_FeatureEvent) A special type of feature which can be located by linear referencing along a TRN_segment or TRN_Path in addition to behaving as a feature by virtue of its having its own attributes, including its own (optional) geometry, independent of the geometry of any TRN_Segment or TRN_Path it is linearly referenced along, e.g., a bridge might be represented as a TRN_FeatureEvent so that it can have attributes such as type, length, and year of construction and its own spatial representation, either as a point, line, or polygon (in future versions of the standard, it may have all three) as well as being linearly referenced along a TRN_Segment or TRN_Path.

Frequency area - An area over which a ground control frequency is valid.

Helipad - The center point of the ‘H’ painted in the helipad.

Helipad FATO - The surveyed and marked area around an “H” where it is safe for the helicopter to land and take off.

Holding bay - Using the ICAO definition, an area where an aircraft can be held or bypassed to facilitate efficient movement of aircraft.

Runway label – A point at which the runway marking is placed.

Secure Identification Area (SIDA) - A polygon, or polygons, that requires credentials and clearances to access (military or civilian security).

Stopway - Part of the runway used as additional space available for landing.

Taxi holding position (Taxiway hold short line) - A runway feature beyond which the nose of the aircraft must have permission to cross.

Touchdown zone - An elevation point on the runway.

Transportation system - The physical and non-physical components representing all modes of travel that allow the movement of goods and people between locations.

3.2 SF21 Definitions

The following definitions were created to support the FAA's SF21 program.

Aircraft Non-movement Areas - All aircraft non-movement areas are used to represent the non-usable areas for aircraft between taxiways, runways, aprons, and/or any combination of the three.

Airport Boundary - The airport boundary is the perimeter of the airport property usually marked by a fence.

Airport Reference Point - The approximate geometric center of all usable runway surfaces.

Airport Surface Lighting - Light structure positions marking the runways, taxiways, aprons, and any other aircraft movement area.

Apron - An apron is a defined area on an airport or heliport intended to accommodate aircraft for purposes of loading or unloading passengers or cargo, refueling, parking, or maintenance.

Arresting Gear Location - Arresting gear, consisting of pendant cables supported over the runway surface by rubber "donuts", is used to prevent aircraft from overrunning runways when the aircraft cannot be stopped after landing or during aborted takeoff.

Blast Pad - A blast pad is a paved area (usually not weight bearing) located beyond the departure runway end, which prevents soil erosion from jet or propeller blast of a departing aircraft.

Centerline - A continuous line that falls along the center of a runway connecting the two photogrammetrically determined thresholds. The centerline shall provide sufficient data in all three dimensions to calculate touchdown zone slopes and runway slopes.

Clearway – A clearway is attached to the threshold of the corresponding runway or to the end of a corresponding stopway as defined by FAR Part 1.

Construction Area - Aircraft movement areas consisting of runways, taxiways, aprons, and vertical structures under construction. (Note: this item requires supplemental temporal information to be valid.)

Control Points – Locations of monumented survey control points at the aerodrome.

Deicing Area - An area comprised of an inner area for the parking of an aircraft to receive deicing treatment and an outer area for the maneuvering of two or more mobile deicing equipment.

Exit Line - A solid yellow line contiguous to the taxiway guidance line, the exit line begins where the endpoint of the taxiway guidance line intersects the runway edge curving onto the runway and extending parallel to the runway centerline marking for a distance of 200 feet.

FATO – Abbreviation for Final Approach and Takeoff Areas. An area over which the final phase of the approach to a hover, or a landing, is completed and from which the takeoff is initiated. (Note: Definition may change in future versions of this document.)

Frequency Areas - Polygons representing designated areas on the surface where a specific frequency is required by ATC or ground control shall be determined as individual polygon objects in the database.

Helipad Threshold – The helipad threshold is based on the predominant wind direction, the helipad threshold position is congruent with the approach/takeoff paths. (Note: Definition may change in future versions of this document.)

LAHSO – Abbreviation for "Land and Hold Short Operation". A LAHSO includes landing and holding short of an intersecting runway, a taxiway, a predetermined point, or an approach/departure flight path. It is marked by a painted white line crossing the width of the runway and indicates the hold short bar for landing aircraft.

Parking Stand Area – Operational areas near parking stands denoted by painted markings.

Parking Stand Location – Painted stand positions on the stand guidance line.

Restricted Area Boundary - A restricted area boundary defines aircraft movement area that is strictly reserved for use by military aircraft and personnel only.

Runway Marking Polygon - Runway marking polygons are painted, closed figures that delineate runway threshold markings, runway threshold bars, displaced threshold bars, runway aiming point markings, and runway touchdown zone markers.

Runway Marking Line - Runway marking lines are painted lines that delineate runway centerline markings (stripes), runway designation markings, demarcation bar, runway side stripe markings, and runway arrow and arrowhead markings.

Runway intersection - The runway intersection feature is defined as the area of intersection between two or more runways or a runway and a stopway.

Runway Shoulder - Runway shoulders are described as pavement areas contiguous to the runway sides that are not intended for use by aircraft.

Stand Guidance Line - A stand guidance line is defined as a centerline (taxiline) in a parking stand area that guides aircraft to parking positions.

Stopways - Stopways are described as an area beyond the takeoff runway no less wide than the runway and centered upon the extended centerline of the runway, able to support the aircraft during an aborted takeoff.

Taxiway Guidance Line - Taxiway guidance lines (taxilines) are also referred to as taxiway centerlines. It is a single continuous yellow line that provides a visual cue to permit taxiing along a designated path.

Taxiway Holding Position - These markings, located at the outer edge of the painted ground marking away from the corresponding runway, identify the locations on a taxiway where an aircraft is supposed to stop when it does not have clearance to proceed onto the runway.

Taxiway Intersection Marking - Installed on taxiways where ATC normally holds aircraft short of a taxiway intersection, the taxiway intersection marking consist of a single dashed yellow line extending across the width of the taxiway.

Taxiway Segment - All taxiway segments include taxiway, apron taxiway, rapid exit taxiway, taxiway intersection, and parking stand taxiway surfaces.

Taxiway Shoulder - Taxiway shoulders are described as pavement areas contiguous to the taxiway sides that are not intended for use by aircraft, but are sometimes provided to prevent blast and water erosion.

Threshold - A Threshold is a point located on the centerline outboard side of each runway threshold bar. All runway information that is related to a landing direction is attached to the corresponding threshold and captured in three dimensions.

TLOF – Abbreviation for Touchdown/Lift-Off Areas. Often called a helipad or helideck, TLOF's are a load bearing, paved or other surface area, normally centered in the FATO, on which the helicopter lands or takes off. (Note: Definition may change in future versions of this document.)

4 Symbols (and Abbreviations)

Symbols and abbreviations that pertain to the GOS Air standard are listed here. Other symbols and abbreviations that have more general application to transportation are listed in the base transportation standard.

AICM - Aeronautical Information Conceptual Model

AIR – Three-letter mnemonic designating the Air mode of the Transportation theme

AIXM - Aeronautical Information Exchange Model

ALP – Airport Layout Plan

FAA – Federal Aviation Administration

FAR – Federal Aviation Regulation

FATO – Final approach and take-off area

FGDC – Federal Geographic Data Committee

GOS – Geospatial One Stop initiative

ICAO - International Civil Aviation Organization

LAHSO - Land and Hold Short Operation

NAS – National Airspace System

NAVAID – Navigational Aid

NSDI - National Spatial Data Infrastructure

SDSFIE – Spatial Data Standards for Facilities Infrastructure and the Environment

SF21 – The FAA Safe Flight 21 initiative

TLOF – Touchdown and lift-off area

TRN – Three-letter mnemonic designating the Transportation theme

5 National Airspace System (NAS)

The National Airspace System (NAS) is comprised of commercial, military and general aviation airports and heliports, thousands of aviation facilities such as navigational aids and communications centers; and the airspace constructs through which aircraft fly. This version of the aviation data exchange model focuses on airports and heliports, although some navigational aides and airspace features are included which are particularly relevant to the depiction of an airport or heliport. These features are included as a temporary placeholder to complete the model of an airport. As airspace and NAVAID features are further detailed in subsequent versions, these features will be properly brought out from under the airport/heliport class and be referenced to the NAS superclass.

5.1 Airport/Heliport

5.1.1 Semantics

An airport/heliport is a specialized type of transportation feature. The airport/heliport model is given in Figure 1. Airport/heliport is an area of the earth's surface, which is designed for the movement of people, goods, and services primarily by aircraft. The geometry is inherited from AirportProperty as GM_Surface, as defined in ISO 19107 [10] and expressed in the airportBoundary attribute.

The airport/heliport is shown to have relationships with the facilities and features necessary to regulate the safe movement of aircraft both on the ground and aloft, the services attendant to air transportation, as well as the relationships of the greater airport facility to the administrative and regulatory authorities and the jurisdictions in which they fall. The airport/heliport also has critical intermodal relationships to other converging transportation modes, including: roads, rail, transit, and waterways.

The central feature of the model depicted in Figure 1 is the Airport. From this, the primary features that constitute an airport/heliport are:

- Runway
- Taxiway
- Apron
- Helipad

To support these primary features, elements such as markings, navigational aides, lighting, shoulders, etc. have been added. To complete the model, other features have been added that comprise the other supporting for the airport. Future versions of the Air model will incorporate these features as they become available:

- Manmade features such as buildings, roads, parking areas, towers, etc.
- Natural features such as terrain, water bodies, etc.

The way in which these features have been modeled is likely to evolve as the primary disciplines for each of these features develops their data exchange model.

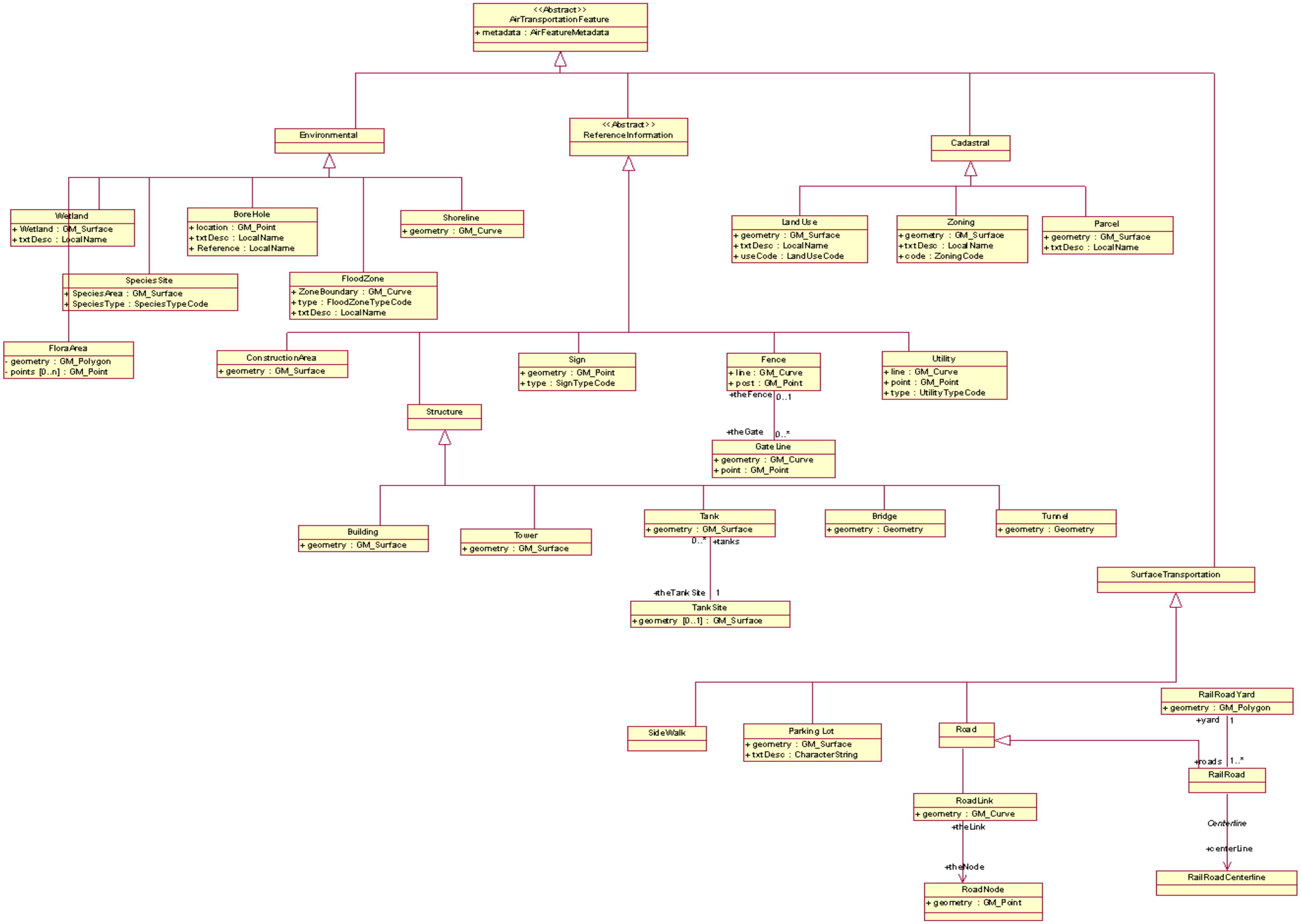

Figure 1-The GOS Air Model

5.2 Runway

The UML diagram for Runway is presented in Figure 2.

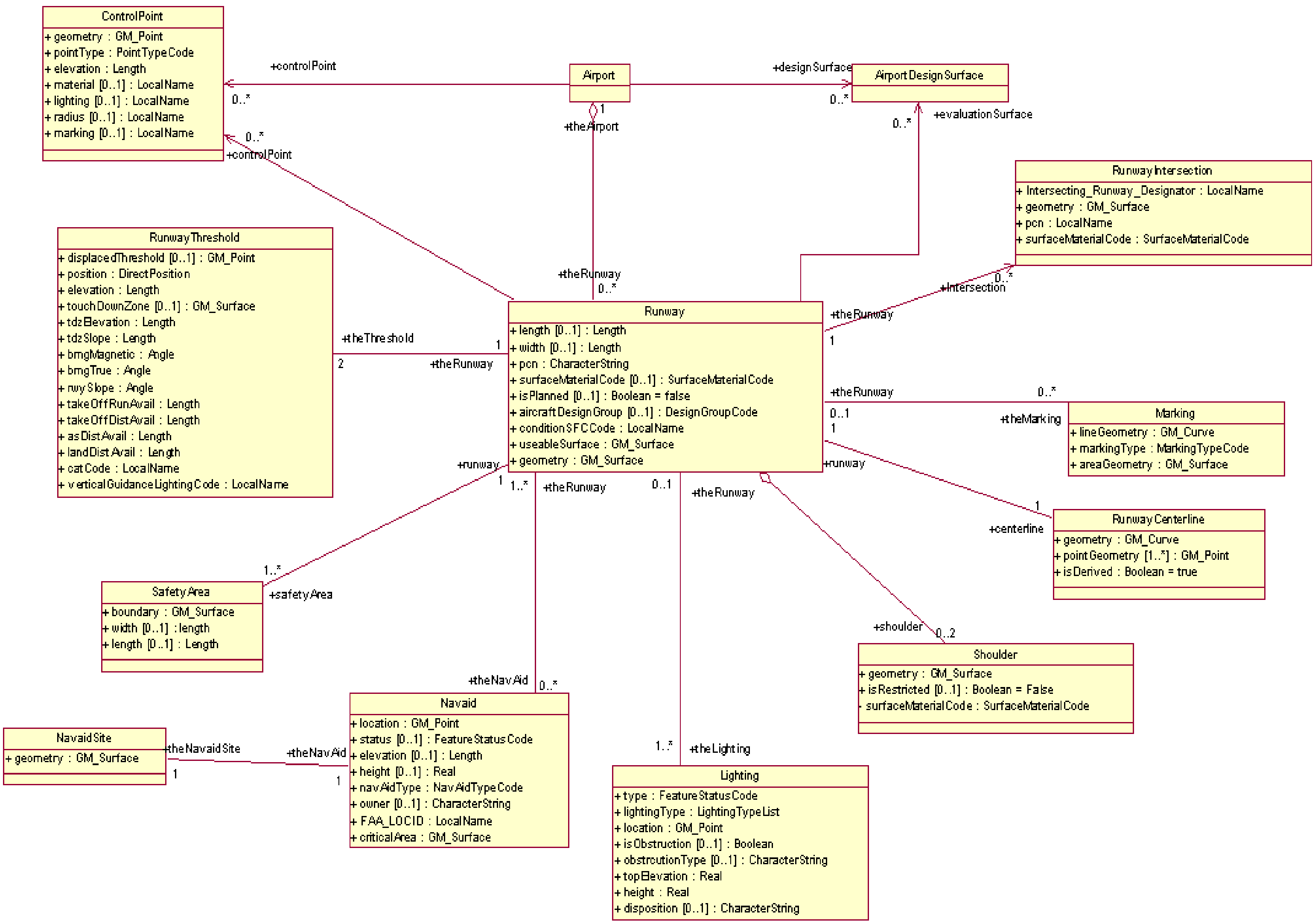

Figure 2-Runway Model

5.2.1 Semantics

Runway is a specific surface type used for the take-off and landing of aircraft. Runway has a geometry of GM_Surface, which it inherits from TRN_Feature. The relationship of runway to airport is depicted in Figure 1. An airport may have one or more runways. Associated with Runway are lighting, blast pad, LAHSO, Label, Clearway, Stopway, and ArrestGearLocation. Each of these features has a many to one relationship with RunwayThreshold.

5.3 Runway Threshold

5.3.1 Semantics

The RunwayThreshold model is depicted in Figure 3. RunwayThreshold is a special subtype of TRN_Feature and inherits its geometry of GM_Surface as defined in ISO 19107.

The threshold is the beginning of that portion of the runway available for a landing. RunwayThreshold has a geometry of GM_Surface. There are two RunwayThresholds associated with each Runway. There may be zero to many Lighting features associated with a Runway or RunwayThreshold. Similarly, there may be zero to many ArrestGearLocations, Labels, Clearways, or LAHSO's associated with the RunwayThreshold. There may be zero to two BlastPads associated with a RunwayThreshold. There may be zero to one Stopways associated with the RunwayThreshold.

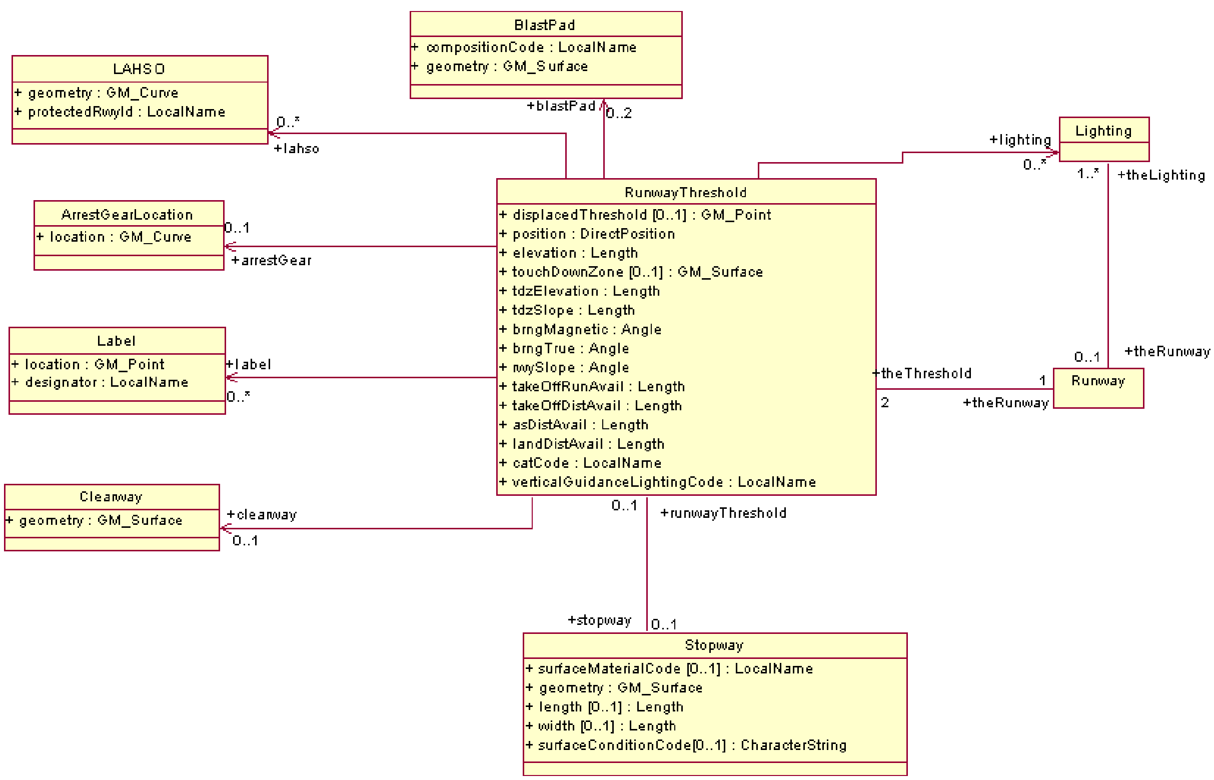

Figure 3-Runway Threshold Model

5.4 TaxiWay

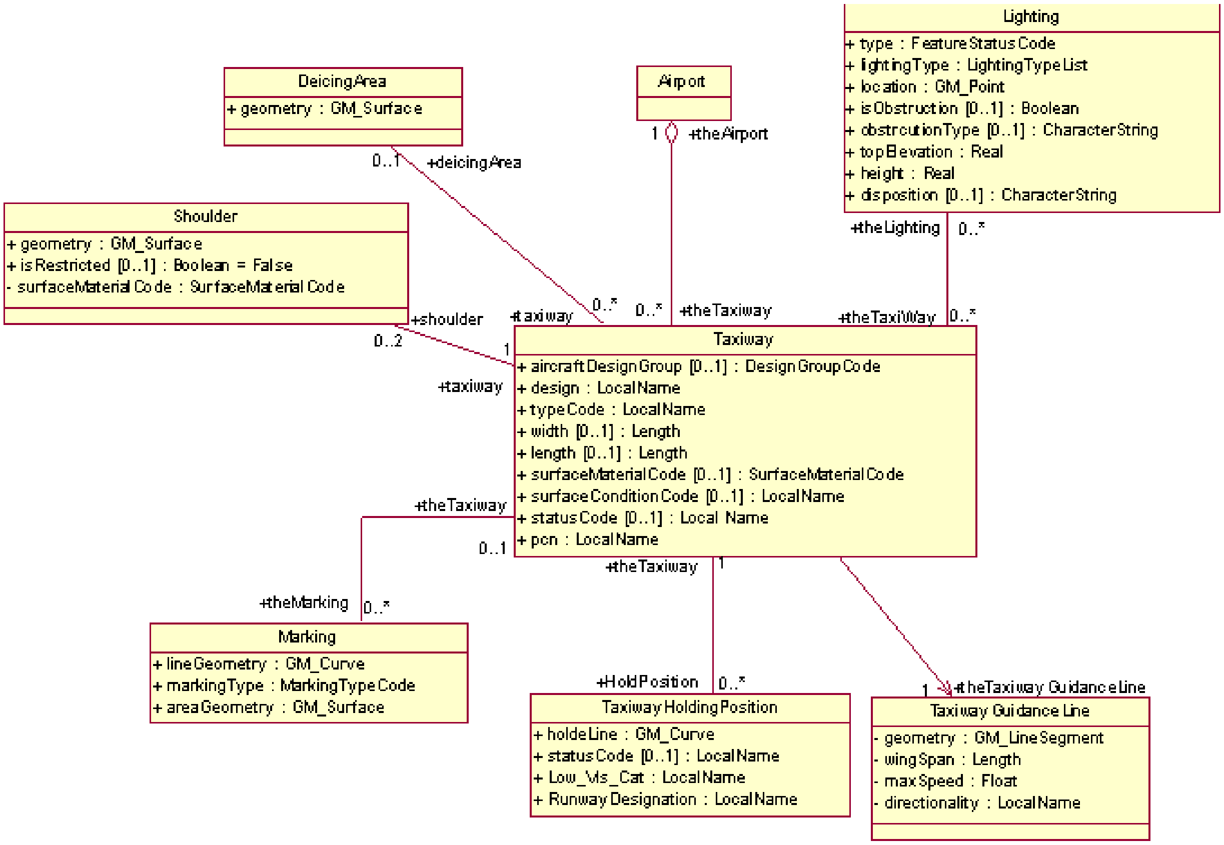

Figure 4-Taxiway Model

5.4.1 Semantics

The TaxiWay is a specialized surface that carries aircraft from the passenger and freight loading zone to the runway, and vice versa. TaxiWay has a geometry type of GM_Surface inherited from Airport. The TaxiWay may have zero or more associated features of Lighting, Taxiway Holding Position, DeIcingArea, and Marking. The TaxiWay may be associated with one TaxiwayGuidanceLine and zero to two Shoulders.

5.5 Apron

The apron model is presented in Figure 5.

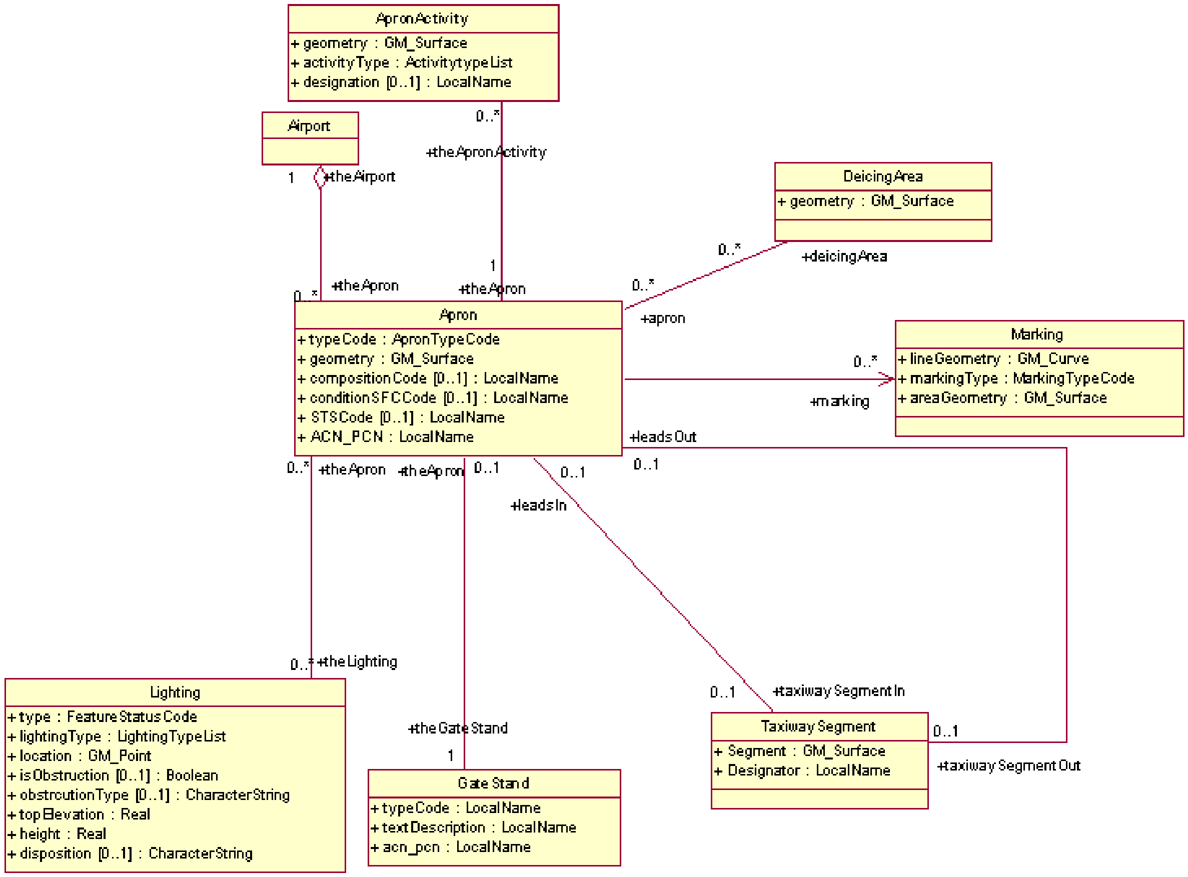

Figure 5-Apron Model

5.5.1 Semantics

The Apron accommodates aircraft for purposes of loading or unloading passengers or cargo, refueling, parking, or maintenance. Its geometry is GM_Surface. Apron is related to Taxiway in that Aprons lead out to TaxiWays and their relationship is one to many.

5.6 Helipad

The helipad model is depicted in Figure 6.

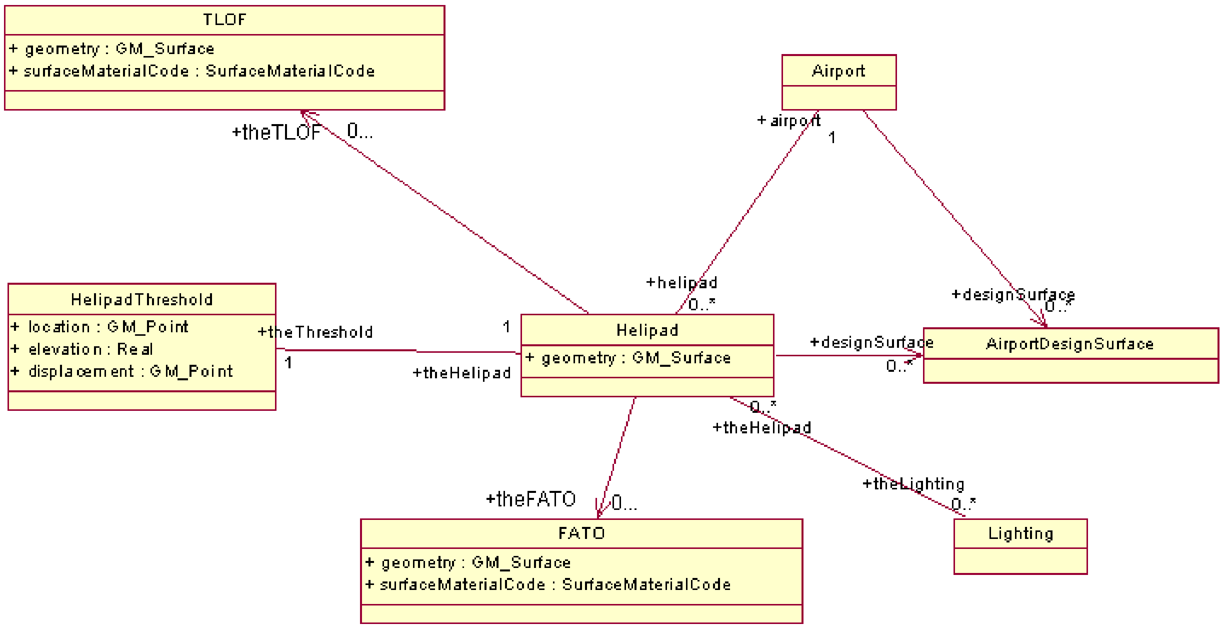

Figure 6-The Helipad Model

5.6.1 Semantics

A one to one relationship exists between Helipad and the HelipadThreshold, which includes elevation and location descriptions for the Helipad. The Helipad is associated with the TLOF (touchdown and lift-off areas), which contain the 'H' marking in a circle designating the area as a load-bearing surface for the take off and landing of helicopters. Helipad may also be associated with Lighting and FATO.

5.7 Marking

Marking is depicted in both Figure 4 and Figure 5.

5.7.1 Semantics

Marking is associated with Runway, TaxiWay, and Apron. Depending on whether the marking is a line or a painted surface, the geometry will take type GM_Curve or GM_Surface.

5.8 Shoulder

The Shoulder is depicted in Figures 4.

5.8.1 Semantics

Shoulder is an area adjacent to Runway, TaxiWay, or Apron and not typically intended for aircraft use. A Boolean value indicates whether the shoulder is restricted. The geometry type for Shoulder is GM_Surface.

5.9 Navigational Aid (NavAid)

NavAid is depicted in Figure 1.

5.9.1 Semantics

NavAid, or navigational aid is sometimes related to runway, though Runway always has at least one NavAid. There is a one to one relationship with NavAidSite and Critical Area. Geometry expressed as GM_Point as defined in ISO 19107.

5.10 Lighting

Lighting is depicted in Figures 1, 4, and 5.

5.10.1 Semantics

Lighting associated with Runway Threshold, Runway, TaxiWay, Helipad, and Apron. Geometry is GM_Point. The relationship of Lighting to these other features is zero to many.

5.11 Air Feature Metadata

The metadata associated with Air Features are depicted in Figure 7, the code list AirFeatureMetadata.

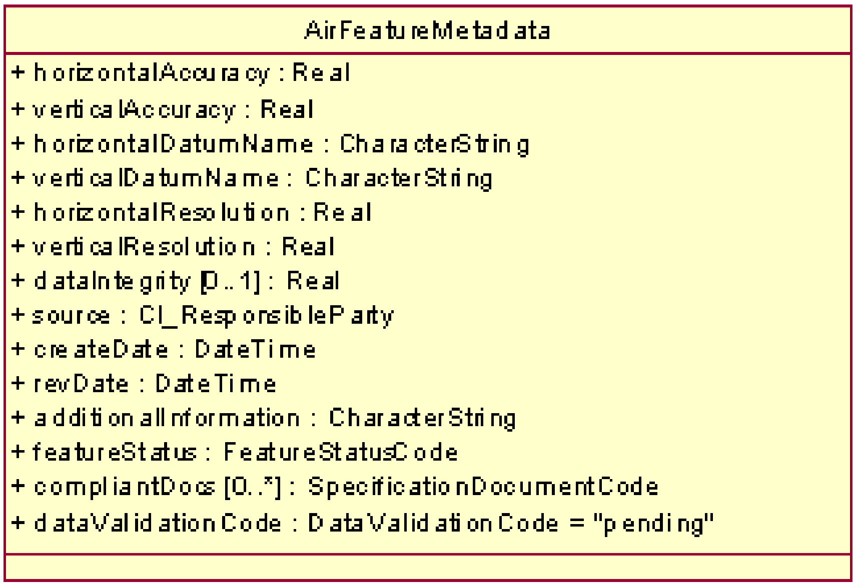

Figure 7-Air Feature Metadata Model

6 Code Lists

The codes applicable to this standard are outlined in Table 1 below.

Table 1-Code List

	ApproachCategoryCode	Definition
1.	A	Speed less than 91 knots
2.	B	Speed 91 knots or more but less than 121 knots
3.	C	Speed 121 knots or more but less than 141 knots
4.	D	Speed 141 knots or more but less than 166 knots
5.	E	Speed 166 knots or more
	Apron Type Code	**Definition**
6.	PassengerLoading	
7.	CargoLoading	
8.	Maintenance	
9.	De-Icing	
10.	Parking	
11.	Fueling	
	DesignSurfaceCode	**Definition**
12.	RunwayProtectionZone	See AC 150/5300-13, paragraph 212
13.	ObstacleFreeZone	See AC 150/5300-13, paragraph 306
14.	ObjectFreeArea	See AC 150/5300-13, paragraph 307
15.	PrecisionObjectFreeArea	See AC 150/5300-13, paragraph 307
16.	TaxiwaySafetyArea	See AC 150/5300-13, paragraph 403
17.	TaxiwayAndTaxilaneObjectFreeArea	See AC 150/5300-13, paragraph 404
18.	ThresholdSittingSurface	See AC 150/5300-13, Appendix 2
	DesignGroupCode	**Definition**
19.	I	Up to but not including 49 ft (15 m)
20.	II	49 ft (15 m) up to but not including 79 ft (24 m)
21.	III	79 ft (24 m) up to but not including 118 ft (36 m)
22.	IV	118 ft (36 m) up to but not including 171 ft (52 m)
23.	V	171 ft (52 m) up to but not including 214 ft (65 m)
24.	VI	214 ft (65 m) up to but not including 262 ft (80 m)
	SurfaceTypeCode	**Definition**
25.	Asphalt	asphalt surface
26.	Concrete	concreate surface
27.	Turf	turf surface
28.	Gravel	gravel surface
	MarkingTypeCode	**Definition**
30.	Precision	
31.	NonPrecision	
32.	Visual	
33.	ExitLine	
34.	TaxiwayEdgeLine	
	PaintTypeCode	**Definition**
35.	AirportReferencePoint	
36.	SpotElevationPoint	
37.	AirportElevationPoint	
38.	RunwayElevationPoint	
39.	SurveyControlPoint	
40.	RunwayEndCoordinates	

41.	Thresholds	
42.	Monuments	
43.	ObstructionPoint	
	NavAidTypeCode	**Definition**
44.	LDIN	
45.	RVR	
46.	GS	
47.	OM	
48.	MM	
49.	IM	
50.	ALS	
51.	ASR	
52.	GlideSlopeAntenna	
53.	AWOS	
54.	ASOS	
55.	DF	
56.	ASDE	
57.	ATCT	
58.	RotatingBeacon	
59.	LOC	
60.	VOR	
61.	DME	
62.	NDB	
63.	VORTAC	
64.	TACAN	
65.	MLS	

Annex A UML notations

The material in this annex is drawn from ISO/TS 19103: Geographic information - Conceptual schema language [11] and ISO 19115: Geographic information - Conceptual schema language [12]. The diagrams that appear in this Standard are presented using the Unified Modeling Language (UML) static structure diagram with the ISO Interface Definition Language (IDL) basic type definitions and the UML Object Constraint Language (OCL) as the conceptual schema language. The UML notations used in this standard are described in Figures 8 and 9.

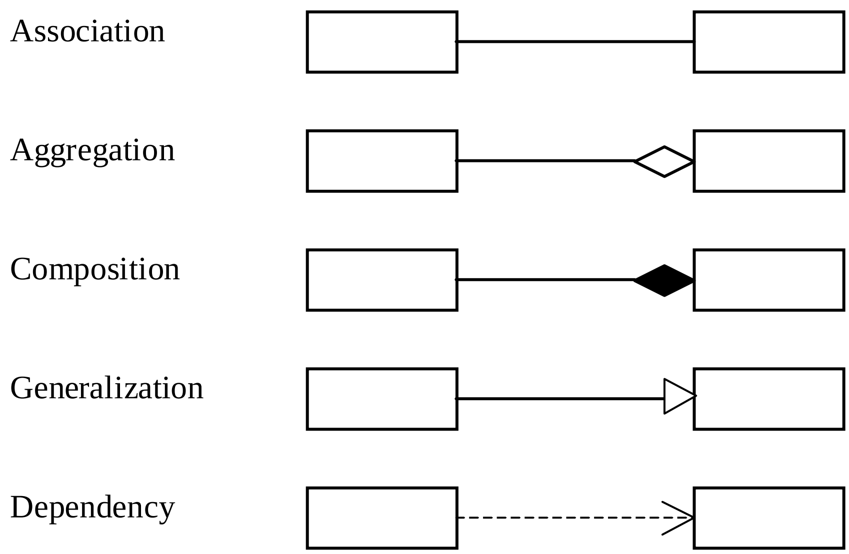

Figure 8–UML notation

UML model relationships

Associations

An association is used to describe a relationship between two or more classes. UML defines three different types of relationships, called association, aggregation and composition. The three types have different semantics. An ordinary association shall be used to represent a general relationship between two classes. The aggregation and composition associations shall be used to create part-whole relationships between two classes. The direction of an association must be specified. If the direction is not specified, it is assumed to be a two-way association. If one-way associations are intended, the direction of the association can be marked by an arrow at the end of the line.

An aggregation association is a relationship between two classes in which one of the classes plays the role of container and the other plays the role of the contained. A composition association is a strong aggregation. In a composition association, if a container object is deleted, then all of its contained objects are deleted as well. The composition association shall be used when the objects representing the parts of a container object cannot exist without the container object.

Generalization

A generalization is a relationship between a superclass and the subclasses that may be substituted for it. The super-class is the generalized class, while the subclasses are specified classes.

Instantiation / Dependency

A dependency relationship shows that the client class depends on the supplier class/interface to provide certain services, such as:

— Client class accesses a value (constant or variable) defined in the supplier class/interface;

— Operations of the client class invoke operations of the supplier class/interface;

— Operations of the client class have signatures whose return class or arguments are instances of the supplier class/interface.

An instantiated relationship represents the act of substituting actual values for the parameters of a parameterized class or parameterized class utility to create a specialized version of the more general item.

Roles

If an association is navigable in a particular direction, the model shall supply a "role name" that is appropriate for the role of the target object in relation to the source object. Thus in a two-way association, two role names will be supplied.

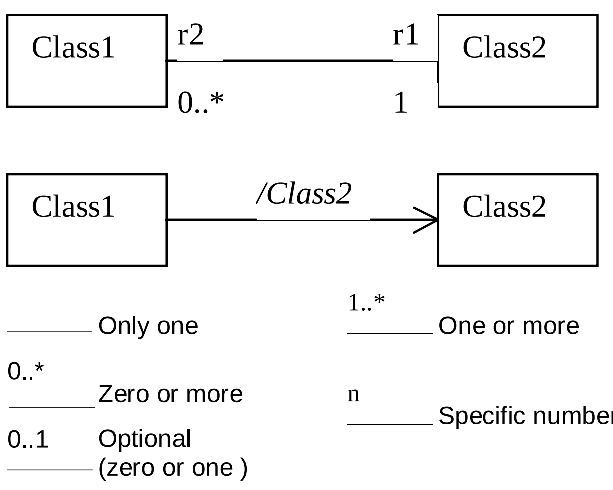

Figure 9–UML roles

Figure 9 represents how role names and cardinalities are expressed in UML diagrams. The top illustration shows that role name "r1"' is Class1's relationship to Class2. The role name "r2" is

Class2's relationship to Class1. The cardinalities show that "zero or many" Class1s are related to "exactly one" Class2.

The bottom illustration in Figure 9 also shows how derived classes will be expressed. The diagram indicates that Class1 is a derived class of Class2. Any attributes and aggregates of Class1 are also derived from Class2.

UML model stereotypes

A UML stereotype is an extension mechanism for existing UML concepts. It is a model element that is used to classify (or mark) other UML elements so that they in some respect behave as if they were instances of new virtual or pseudo metamodel classes whose form is based on existing base metamodel classes. Stereotypes augment the classification mechanisms on the basis of the built-in UML metamodel class hierarchy. Below are brief descriptions of the stereotypes used in this Standard:

a) <<DataType>> descriptor of a set of values that lack identity (independent existence and the possibility of side effects). Data types include primitive predefined types and user-definable types. A DataType is thus a class with few or no operations whose primary purpose is to hold the abstract state of another class.
b) <<CodeList>> used to describe a more open enumeration. <<CodeList>> is a flexible enumeration. Code lists are useful for expressing a long list of potential values. If the elements of the list are completely known, an enumeration should be used; if the only likely values of the elements are known, a code list should be used.
c) <<Abstract>> class (or other classifier) that cannot be directly instantiated. UML notation for this to show the name in italics.
d) <<Package>> cluster of logically related components, containing sub-packages.
e) <<Leaf>> package that contains definitions, without any sub-packages.