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Enabling INSPIRE for Aeronautical Information Management

by

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Abstract

From the beginning of civil aviation cross-border geospatial information is in common use because geographic realities have a direct impact on air traffic services provided (e.g. airspace structure, air route and waypoint characteristics). So far geospatial aeronautical information is mainly stored, visualised, and published separately by States or air navigation service providers using analogue aeronautical charts of different types and scales.

But there is a proliferation of operating requirements to data quality, timeliness, provision, and exchange of digital aeronautical information due to safety reasons. So today's main goal of aeronautical information management (AIM) is to provide aeronautical data to in-house or international partners or users. The importance of geospatial methods and infrastructure concepts like a spatial data infrastructure (SDI) is growing steadily in AIM because the benefits are realised in the aviation industry.

A review of future developments and imperatives concerning SDI and AIM clarifies a connection between these topics in the European initiatives of INSPIRE (Infrastructure for Spatial Information in Europe) and SESAR (Single European Sky ATM Research Programme). So far the aviation community did not consider the INSPIRE initiative as an adequate platform for data provision and exchange.

The scope of this thesis is to evaluate the draft guidelines of the INSPIRE Data Specification on Transport Networks answering the question whether from AIM perspective the INSPIRE data model concept, especially on air transport networks, is suitable as an aeronautical data exchange platform in the sense of a European SDI. The necessary modifications and enhancements concerning overlapping spatial data themes of the INSPIRE initiative as well as the used temporal and topology concepts are elaborated. Finally changes in the data model itself to ensure the usefulness of INSPIRE as an aeronautical SDI are successfully undertaken by using the Unified Modeling Language (UML) for specification.

Key words: spatial data infrastructure (SDI), aeronautical information management (AIM), INSPIRE, UML, aeronautical data model

Kurzfassung

Seit jeher werden grenzüberschreitende Geodaten in der Luftfahrt eingesetzt, da geographische Gegebenheiten direkte Auswirkungen auf die angebotenen Flugverkehrsdienste, wie die Luftraumstruktur oder Luftstraßen, haben. Die Speicherung, Visualisierung und Publikation dieser geographischen Luftfahrtinformationen erfolgte bisher in Form gedruckter Luftfahrtkarten unterschiedlicher Thematik durch die jeweils zuständigen Behörden.

In der Luftfahrt steht eine besondere Bedeutung der Sicherheit außer Frage. Daraus lässt sich eine steigende operative Notwendigkeit der Verteilung und des zeitgerechten Austausches von qualitätsgesicherten, digitalen Luftfahrtinformationen an unternehmensinterne und internationale Kunden ableiten, die heute eine Hauptaufgabe des Luftfahrtinformationsdienstes darstellt. Damit verbunden ist ein Anstieg der Relevanz von Methoden und Konzepten aus der Geoinformatik, im speziellen einer Geodateninfrastruktur (GDI), im Luftfahrtinformationsdienst. Auch in der Luftfahrtindustrie wird die Bedeutungszunahme der neuen Konzepte der Geoinformatik und deren Umsetzung verstärkt zur Kenntnis genommen.

Eine Bewertung der zwingenden Anforderungen und zukünftigen Entwicklungen einer GDI und dem Luftfahrtinformationsdienst verdeutlicht die bestehende Verbindung zwischen diesen bis dato stark voneinander differenziert betrachteten Bereichen in den europäischen Initiativen INSPIRE (Infrastructure for Spatial Information in Europe) und SESAR (Single European Sky ATM Research Programme). Bisher wurde die INSPIRE-Initiative von Seiten der Luftfahrt nicht als adäquate Plattform für Datenverteilung und -austausch betrachtet.

Ziel dieser Arbeit ist eine Evaluierung der vorläufigen INSPIRE-Richtlinie zur Datenspezifikation für Verkehrsnetze. Es wird versucht die aufgeworfene Frage zu beantworten, ob aus der Sicht des Luftfahrtinformationsdienstes das darin enthaltene Datenmodell für den Luftverkehr als Plattform für den Austausch von Luftfahrtinformation im Sinne einer europäischen GDI brauchbar ist. Basierend auf den Ergebnissen werden notwendige Anpassungen und Verbesserungen der Richtlinie hinsichtlich der Abhängigkeit zu anderen räumlichen Datensätzen, sowie der zu verwendenden Zeit- und Topologiekonzepte vorgeschlagen. Schließlich kommt die Unified Modeling Language (UML) zur Beschreibung und Abbildung der notwendigen Verbesserungen und Erweiterungen des Datenmodells, das den Anforderungen von INSPIRE und dem Luftfahrtinformationsdienst entspricht, zum Einsatz.

Schlüsselwörter: Geodateninfrastruktur (GDI), Luftfahrtinformationsdienst, INSPIRE, UML, aeronautisches Datenmodell

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Most of all I owe special debt of gratitude to my girlfriend Mag. BERENIKE ECKER MES, my parents GÜNTER and MARIA KLINGER, my sister DANIELA KLINGER, my nephew SEBASTIAN, and my friends for their support and forbearance in challenging phases of my studies.

Science Pledge

By my signature below I certify that

- my thesis is entirely the result of my own work.
- I have cited all sources I have used in my thesis and I have always indicated their origin.
- I never submitted this topic inland or abroad as an examination paper in any similar form at another examination board.
- this master thesis matches with the one evaluated by the advisor.
- all performances of this work, that are inherited literally or analogously, are quoted correctly.

30.04.2009 Mag. Klinger Gernot

Date Signature

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List of abbreviations

ADIZ	Air defense identification zone
ADQ	draft implementing rule on aeronautical data and information quality
AIM	Aeronautical information management
AIP	Aeronautical information publication
AIRAC	Aeronautical information regulation and control
AIS	Aeronautical information services
AIXM	Aeronautical information exchange model
AMDB	Aerodrome mapping data base
AMDT	Amendment
ANSP	Air navigation service provider
ARP	Aerodrome reference point
ATC	Air traffic control
ATM	Air traffic management
ATS	Air traffic service
ATZ	Aerodrome traffic zone
CAD	Computer-aided design
CANSO	Civil Air Navigation Services Organisation
CEN	European Committee for Standardization
CRC	Cyclic redundancy check
CSDI	Corporate spatial data infrastructure
CTA	Control area
CTR	Control zone
DEM	Digital elevation model
DTM	Digital terrain model
EAD	European AIS Database
EC	European Commission

EGM	Earth Gravitational Model
ESDI	European spatial data infrastructure
eTOD	Electronic terrain and obstacle data
EU	European Union
FIR	Flight information region
FL	Flight level
FMS	Flight management system
ft	Foot/feet
GIS	Geographic information system
GML	Geography Markup Language
GNM	Generic Network Model
GPS	Global Positioning System
GSDI	Global spatial data infrastructure
IAP	Instrument approach procedure
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IFR	Instrument flight rules
INSPIRE	Infrastructure for Spatial Information in Europe
ISO	International Organization for Standardization
km	Kilometre
kt	Knot
m	Metre
MSL	Mean sea level
NextGen	Next Generation Air Transport System
NM	Nautical mile
NOTAM	Notice to airmen
NSDI	National spatial data infrastructure
OCA	Oceanic control area
OGC	Open Geospatial Consortium
OMG	Object Management Group

RNAV	Area navigation
SES	Single European Sky
SESAR	Single European Sky ATM Research Programme
SDI	Spatial data infrastructure
SI	International System of Units
SID	Standard instrument departure
SOA	Service oriented architecture
SRA	Special rules area
STAR	Standard arrival route
SVFR	Special visual flight rules
SWIM	System wide information management
TMA	Terminal control area
TMZ	Transponder mandatory zone
TRA	Temporary reserved area
TSA	Temporary seggregated area
UIR	Upper information region
UML	Unified Modeling Language
UN	United Nations
VAP	Visual approach procedure
VFR	Visual flight rules
W3C	World Wide Web Consortium
WGS	World Geodetic System
WWW	World Wide Web
XML	Extensible Markup Language

1 Introduction

From the beginning of civil aviation geospatial information is in common use. The navigation of aircraft and the control of air traffic demand extensive knowledge about geographic realities because they have an impact on air traffic services (ATS) provided (e.g. airspace structure, air route and waypoint characteristics). Furthermore civil aviation does not stop at State boundaries and is international by its nature.

So far geospatial aeronautical information is mainly stored, visualised, and published separately by States or delegated air navigation service providers (ANSP) using aeronautical charts of different types and scales. But there is a proliferation of operating requirements to data quality, timeliness, provision, and exchange of digital aeronautical information due to safety reasons.

So today's main goal of aeronautical information management (AIM) is to provide aeronautical data to in-house or international partners or users. The importance of geospatial methods and infrastructure concepts developed by geographic information science is growing steadily in AIM because the benefits are realised in the geospatial niche of aviation.

Spatial data infrastructure (SDI) is the current keyword in the growing geoinformation industry. RAJABIFARD, A. and I. WILLIAMSON (2002) define an SDI as the interaction of the widest possible group of potential users, the network linkages and access, the political issues, the standards, and the data of different data sources for the effective flow and interoperable exchange of spatial information at different levels based on partnerships. Many organisations, administrations, and companies spend a lot of money on the establishment of an SDI. Now it is a known fact that an SDI does not have a primary advantage but is the essential precondition for a developing geospatial data exchange (MICUS, 2004).

At present AIM is not a typical field of application for SDIs although the essential parameters are given. An SDI for aeronautical purposes at a European level is contemplated by EUROCONTROL (VAN DER STRICHT, S. and Å. STANDAR, 2007; REID, K., 2008) but the political (and economic) decisions are heading for another direction as the concept of the European AIS Database (EAD) - a single, centralised reference database of harmonised and quality-assured aeronautical information - illustrates.

In the context of air traffic management (ATM) the field of geoinformation is a small share that is often not inhabited by experts or decisions are driven by the aviation industry only. The main focus of attention in ATM lies in air traffic control which is the daily business and makes the money. It is a fact that an SDI is a major and long-term investment and there is the high need to demonstrate the benefit for the user of which there are many. A change of the philosophy behind ATM is needed, a concession that geospatial data, related methods, and infrastructures are the common basis (ICAO, 2004b; EUROCONTROL, 2006; SESAR CONSORTIUM, 2006b).

The Single European Sky ATM Research programme (SESAR) is the European ATM modernisation programme and combines technological, economic, and regulatory aspects. Finally a global, distributed aeronautical data management environment, managing aeronautical information as well as technical fundamentals shall be established (EUROCONTROL, 2006; SESAR CONSORTIUM, 2006b). Due to the fact that the majority of air navigation data has a spatial dimension, a spatially enabled information management system like an SDI would lead towards a common aim.

The current drafts of the National SDI (NSDI) of Austria and of the Infrastructure for Spatial Information in Europe (INSPIRE) contain the management and provision of aeronautical information. But are they suitable for AIM?

1.1 Motivation

The initial idea for this work arose during discussions concerning the future of the working group I am assigned to in my company, an ANSP. Although we are a small bunch of people we have a big impact on the planning phase of ATM because of the management and provision of geospatial data.

Moreover it is a challenge shaping future key issues in AIM right from the start of the transition from analogue-graphical data exchange to digital data exchange of aeronautical information at an international level.

Finally the work shall remove the predominant lack of awareness and additionally support the capacity building in the aviation industry concerning the essential convergence of geographic information system (GIS) or SDI and AIM. Besides the International Civil Aviation Organization (ICAO) has already identified that top-quality spatial information including its (international) provision and exchange improves the safety of air traffic (ICAO, 2004b).

1.2 Project scope and methodology

The scope of the project consists of a review of the draft guidelines of the INSPIRE Data Specification on Air Transport Networks (INSPIRE, 2008b) answering the question whether from AIM perspective the INSPIRE data model concept, especially on air transport networks, is suitable as an aeronautical data exchange platform in the sense of a European SDI. This could establish INSPIRE as a counterpart to the EAD initiative. The necessary adjustments in the data model for the usefulness of INSPIRE as an aeronautical SDI are undertaken by using the Unified Modeling Language (UML) for specification.

1.3 Expected results

The expected result of this work is the provision of a data model consistent with the INSPIRE concept in terms of connectivity to other spatial data themes. Moreover the UML specification of the data model has to be suitable for AIM needs and complies the international aviation requirements published in ICAO Annex15 (ICAO, 2004b). The final data model shall be expandable to provide the opportunity to integrate increasing future needs of AIM.

To accomplish this goal the recently published draft guidelines of the INSPIRE Data Specification on Transport Networks, especially air transport, are reviewed whether they meet the needs. Based on the results a modification of the data model including its enhancement with attributes needed in AIM using UML specification is provided.

1.3.1 Issues not covered

This thesis deals with spatial data themes concerning the domain of AIM only. Other technical information important to aeronautical purposes like meteorological information are only mentioned where appropriate but there is no UML specification.

The technical realisation of the data model or of an SDI for aeronautical purposes is not implemented in this work that remains on a formal basis.

There is no intention in this thesis to evaluate the INSPIRE concept per se and the national approach to SDI implementation at any level.

Another issue not covered by this work are the written operation guidelines to promote as well as put through the results of this work on a political level in Austria or Europe.

1.4 Audience

This thesis may be a contribution to every ANSP and international authorities like EUROCONTROL or ICAO and their member states raising the awareness that INSPIRE could be an important piece of a puzzle in future AIM. As this work integrates aeronautical information into an SDI at a European level it may also be of interest in the field of geographic information science and SDI-related research because it highlights a seminal niche application. Finally the INSPIRE Working Group on Transport Networks may benefit from this work because it shows what AIM is expecting from INSPIRE in order to implement it in their future considerations.

1.5 Structure of the thesis

This master thesis starts with a short introduction in chapter 1 where motivation, project scope and methodology, expected and not expected results as well as the audience are covered.

The challenge of chapter 2 is to unite the theoretical backgrounds of geographic information science in special consideration of spatial data infrastructures and aeronautical information management to provide a common basis for the divergent audience.

Chapter 3 contains the clarification of the theoretical approach for the project of the thesis, the used methodology of UML specification, and the review of the draft guidelines of the INSPIRE data specification on air transport networks.

The implementation of the data model is described in chapter 4. General considerations concerning mandatory improvements, the modified topology concept, and enhanced spatial object types (or feature types), enumerations, and code lists are presented. Furthermore this chapter includes a conclusion of the results of this thesis.

Finally chapter 6 provides a summary of this work, discusses the results, and looks into the near future outlining potential further investigations.

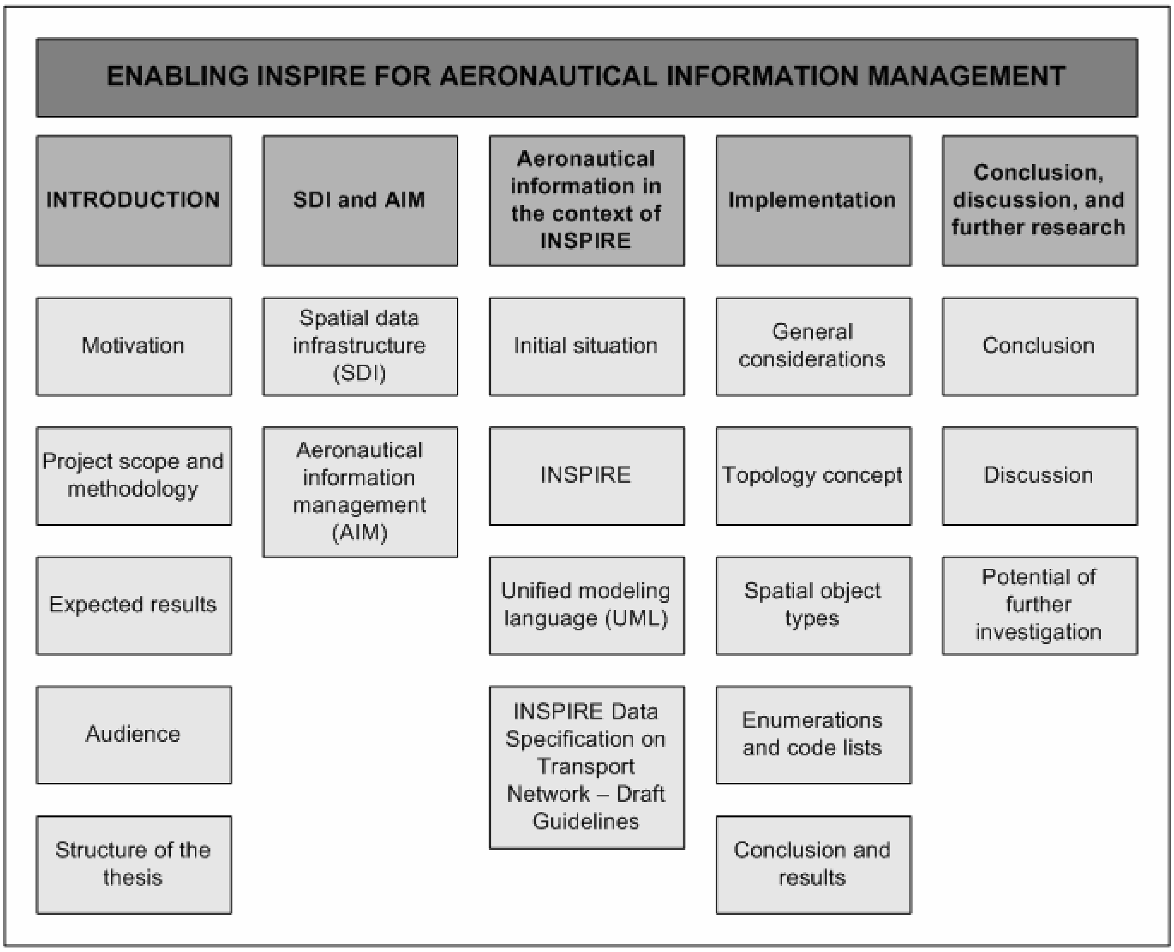

Fig. 1: Structure of the thesis

2 Spatial data infrastructures and aeronautical information management

2.1 Spatial data infrastructure (SDI)

2.1.1 Introduction

Adapted from many years of experience, 80% of all business data and related decisions are spatially enabled (BILL, R., 1999; GABRIEL, P., 2001; TEEGE, G., 2001; LEHMANN, A. ET AL., 2002). Spatial data are data about objects that are spatial referenced by coordinates in a defined spatial reference system. Spatial data consist of spatial base data and spatial thematic data (LEHMANN, A. ET AL., 2002). On the one hand spatial base data cover data that are characterising topography and real estates on the surface of the earth without reference to special interest. On the other hand spatial thematic data are defined as the (spatial) data which are collected and used by specialist disciplines (GG, 2001-2008).

During the last two decades the amount of spatial data that has been collected and stored in digital form has increased dramatically due to the rapid development of spatial data capture technologies like Global Positioning System (GPS) or remote sensing. Moreover the usability of data collection and communication technologies is steadily improving. Despite an increasing amount of users, a good portion of these data is not used as effectively as they should (PHILLIPS, A. ET AL., 1999; RAJABIFARD, A. and I. WILLIAMSON, 2002). Spatial data hold a high economic relevance that is increasing steadily, although there are still technical and organisational deviancies (TEEGE, G., 2001). Due to lack in transparency of data availability and user-oriented data products only 10-30% of the geospatial market is efficiently used today, so there is much to do (MICUS, 2004).

2.1.2 Definition

GIS is the term that is commonly used to refer to the software packages that are capable of collecting, integrating, managing, storing, processing, and visualising spatial and non-spatial data to yield the spatial information that is used in decision making (BILL, R., 1999; TOMLINSON, R., 2003; LONGLEY, P. ET AL., 2005). Commonly a GIS and associated data are used as a tool on a project basis. If these spatial data are reused for other projects, GIS changes to a sharing resource for different applications (TEEGE, G., 2001). A GIS can be transformed to an SDI by establishing cooperation and collaboration of different disciplines and authorities by assigning custodianships and usage privileges for subsets of data. Then users in the general community are able to expect the data to be available, and with network technology, to be accessible transparently (PHILLIPS, A. ET AL., 1999).

SDI is an innovation that is maintained by many GIS concepts and technologies, as well as the internet and related telecommunications as well as network technology. SDI is understood and described differently by stakeholders from different disciplines and different administrative/political levels. Whilst these various definitions provide a useful base for the understanding of diverse aspects of SDI, or SDI at a snapshot in time, the variety of descriptions has resulted in a fragmentation of the identities and nature of SDI. The absence of a more holistic representation and understanding of SDI limits the ability to describe its evolution in response to the technical and user environment. Existing definitions are often slow to incorporate the concept of an integrated, multi-levelled, and dynamic SDI. (CHAN, T. ET AL., 2001; RAJABIFARD, A. and I. WILLIAMSON, 2002)

According to GROOT, R. and J. MCLAUGHLIN (2000) an SDI "encompasses the networked geospatial databases and data handling facilities, the complex of institutional, organisational, technological, human, and economic resources which interact with one another and underpin the design, implementation, and maintenance of mechanisms facilitating the sharing, access to, and responsible use of geospatial data at an affordable cost for a specific application domain or enterprise."

Similar components but in a more process-orientated view are included in the characterisation by RAJABIFARD, A. and I. WILLIAMSON (2002) where SDI is described as the interaction of the widest possible group of potential users, the network linkages and access, the political issues, the standards, and the data of different data sources for the effective flow and interoperable exchange of spatial information at different levels (scale) based on partnerships (Fig. 2).

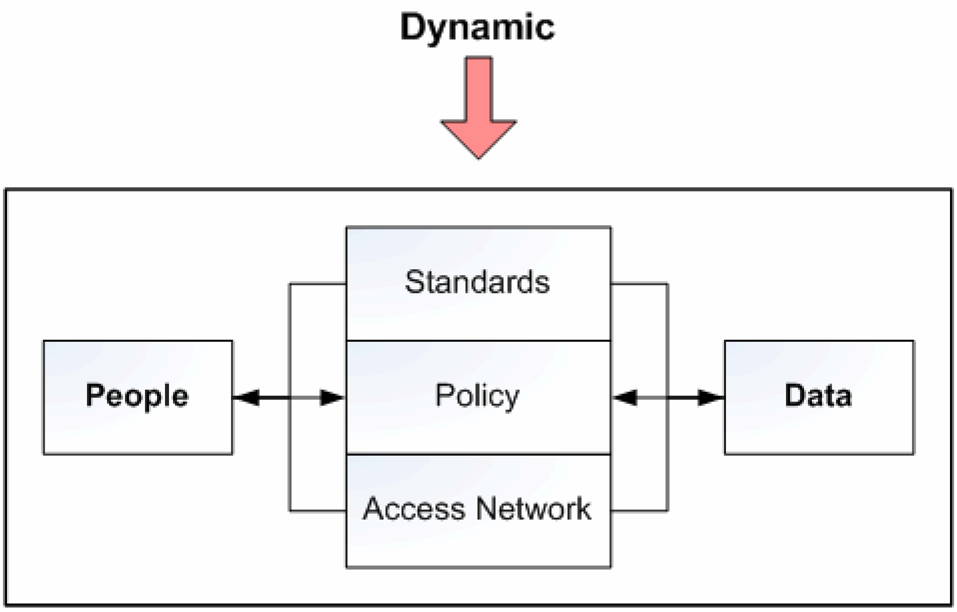

Fig. 2: Nature and relations between SDI components (RAJABIFARD, A. and I. WILLIAMSON, 2002)

The SDI Cookbook (NEBERT, D., 2004) specifies that the term SDI denotes the relevant base collection of technologies, policies, and institutional arrangements that facilitate the availability of and access to spatial data. An SDI provides a basis for spatial data discovery, evaluation, and application for users and providers within all levels of application. The word infrastructure is used to promote the concept of a reliable, supporting environment that facilitates the access to spatial information using a minimum set of standard practices, protocols, and specifications. Moreover an SDI facilitates the conveyance of virtually unlimited packages of geographic information.

Even in 1999 PHILLIPS, A. ET AL. pointed out that an SDI, solely driven by technology, will not work if communication channels, standards and procedures, partnerships, and data have not been developed. Today the implementation of SDIs is mostly user driven.

An SDI must be more than a single data set or database. An SDI hosts geographic data and attributes, sufficient documentation in terms of metadata, a means to discover, visualise, evaluate, and provide access to the geographic data (e.g. catalogues and web mapping). Different applications of the data are supported by additional services or software. To make an SDI functional, it must also include the organisational agreements needed to coordinate and administer it on multiple levels. An SDI provides the ideal environment to connect applications to data – influencing both data collection and applications construction through minimal appropriate standards and policies. (NEBERT, D., 2004; NEDOVIC-BUDIC, Z. and N. BUDHATHOKI, 2006)

In 2004 WYTZISK, A. and A. SLIWINSKI concluded that current SDI definitions are of too static nature as well as there are marginal provisions for users. An adjusted approach must also focus on scalability as well as adaptability issues.

2.1.3 SDI architecture

2.1.3.1 SDI concept

At all political/administrative levels increasing interests are given to SDI because of the recognition that SDI promotes economic development and environmental management. Despite the international interest and activities towards SDI development the innovative concept and justification of SDI are still unclear even among key players. (CHAN, T. ET AL., 2001)

An SDI provides an environment within which stakeholders like organisations or nations interact with technologies to foster activities for using, managing, and producing geographic data at different political/administrative levels. SDI is fundamentally about facilitation and coordination of the exchange and sharing of spatial data in the spatial data community. This includes the economic aspects of saving resources, time, and effort. SDI comprises dynamic partnerships between different stakeholders at different political/administrative levels. Cooperation between users and producers of spatial data is needed to nurture the means and environment for spatial data sharing and development. The principal objective for developing an SDI for any political and administrative level is to improve economic, social, and environmental decision-making at this level. SDIs have become an innovative and very important method in determining the way in which spatial data are used throughout an organisation, a nation, different regions, and the world. The design and implementation of an SDI needs a designing of technology, institutions, the legislative and regulatory frameworks, and acquiring of new types of skills. All member parties should benefit from an SDI to persuade other non-participating members to join. This is essential because a growth in membership means a widening of the data pool which enables the realisation of further benefits and economies of scale. (RAJABIFARD, A. and I. WILLIAMSON, 2002)

2.1.3.2 SDI components

A well developed SDI comprises the fundamental spatial datasets as well as the interrelationships between these datasets, the (political) management of them, and the means of access to, and distribution of, those data (COLEMAN, D.J. ET AL., 1997; PHILLIPS, A. ET AL., 1999; LEHMANN, A. ET AL., 2002; RAJABIFARD, A. and I. WILLIAMSON, 2002):

- *Data*: Today (spatial) data are obviously the most important content of an SDI because an SDI can not exist without spatial data. Spatial data have to be accurate, up-to-date, consistent, kept redundancy-free, and treated by experts at an appropriate level only to stay useful for SDI application. During the SDI development special attention has to be turned on mainly project-specific legacy data. Depending on the size of the SDI the amount of legacy data increases. Legacy data are typically stored in all sorts of different proprietary formats and reference systems, which make using, sharing, and selling of the data difficult if they are not transferred to a common format. Usually a metainformation system provides a detailed overview of the existing spatial data including their sources and provides the possibility to compare and evaluate the variety of spatial data. This allows even untrained customers to benefit from the SDI.

- *People (including partnerships)*: One of the most important first steps in the creation of an effective SDI is the investment in an efficient communication model between stakeholders/users concerned with spatial data. This allows the establishment of partnerships, standards, and procedures which enables the data to be shared, traded, or purchased amongst the different data custodians. It is a precondition that all participants are counting on the same basic understanding concerning the mode of action and the building blocks of the SDI. The individuals and organisations that access and use the infrastructure to acquire geospatial data to meet their requirements are an important component for a successful SDI too. They add value by developing new information services and products.

- *Standards*: Common standards and procedures by the International Organization for Standardization (ISO), Open Geospatial Consortium (OGC), and World Wide Web Consortium (W3C) facilitate the sharing of (spatial) data across the SDI to a greater extent and ensure the best possible utilisation of the data. The sharing of datasets in different formats (e.g. legacy data) via an SDI is difficult due to the many incompatibilities that exist between the data formats. The spatial data network is an open one where spatial data are not centrally managed. Each provider is obliged to administer and maintain his data independently in time.

- *Policy*: During the development of an SDI partnerships and institutional arrangements are extremely important as they are major achievements. Cooperation is often seen by companies as giving up their competitive edge to create, share, trade, and sell data with other companies. If the custodians of the data are not willing to share or sell their data, a good and transparent network of metadata and transfer standards is useless.

- *Network Access*: SDI establishment involves actual technology that deals with communication over networks and technology that is required to allow data to acquire an infrastructure status. Not only the spatial data capture technologies are important, but also common data models, standards, etc. have to be developed in order to make the dataset as portable as possible. Spatial data services use the available spatial data and prepare them for the user. This implies a usable, quick, and easy way of locating and applying of spatial data and spatial data services. Additionally data refinement processes can be offered to the user.

2.1.3.3 Hierarchy

Many countries are developing SDIs at different political-administrative levels ranging from corporate to global levels to facilitate better management and utilisation of spatial data assets. The most important objectives of these initiatives are to promote economic development, to stimulate government better, and to foster environmental sustainability. Based on their relationships the model of SDI hierarchy can be described as a pyramid of building blocks (Fig. 3). (RAJABIFARD, A. ET AL., 2000; RAJABIFARD, A. and I. WILLIAMSON, 2002)

Recent related research indicates that SDI is multi-levelled in nature, formed from a hierarchy of inter-connected SDIs at corporate, local, state or provincial, national, regional (multi-national) and global levels (CHAN, T. ET AL., 2001; NEBERT, D., 2004; MASSER, I., 2006) where the horizontal (combining various themes) and vertical (local to national to eventually global) integration of data is achieved (COLEMAN, D.J. ET AL., 1997; RAJABIFARD, A. and I. WILLIAMSON, 2002). There is a clear need for a more coordinated and connected approach in developing spatial data infrastructures at different levels around the world (NEDOVIC-BUDIC, Z. and N. BUDHATHOKI, 2006).

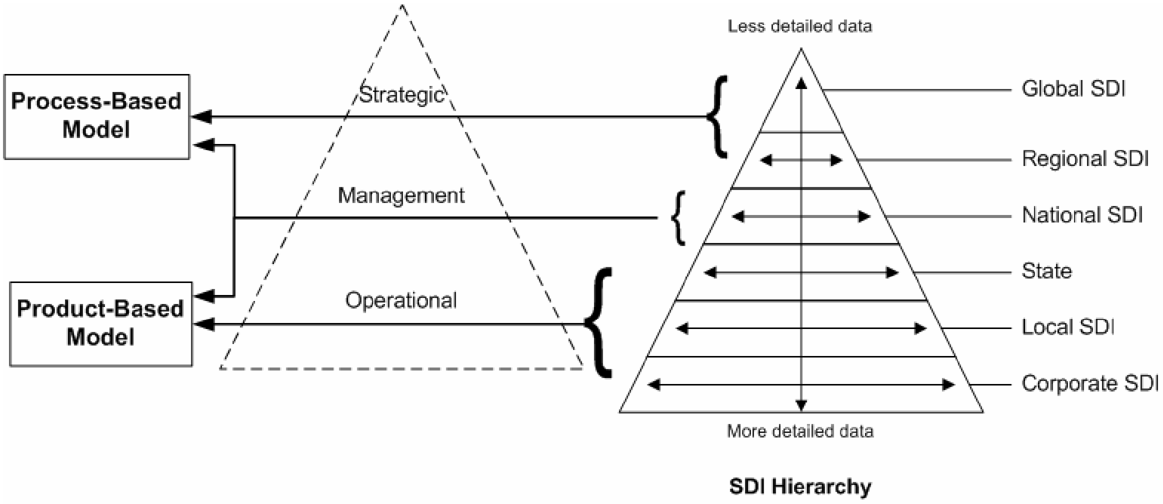

Fig. 3: Relationships between SDI hierarchy and different models of SDI development (RAJABIFARD, A. ET AL., 2006)

The (vertical) relationships among different levels of SDIs are complex and of different characteristic due to the dynamic, inter- and intra-jurisdictional nature of SDIs. The importance of horizontal relationships increases with the spatially adjacency or proximity of respective jurisdictions (RAJABIFARD, A. and I. WILLIAMSON, 2002). Special partnerships are required to integrate SDI capabilities at different levels. The SDI capabilities developed at one level are not easily transferred to users at another level (CHAN, T. and I. WILLIAMSON, 1999).

A *corporate SDI (CSDI)* is the lowest level in the hierarchy of SDIs worldwide. A CSDI is formed primarily by sharing and integrating data from different business units in an organisation and/or with other companies. Collaborating organisations can provide data on different levels (e.g. local and national). The further development of SDIs at other levels can benefit from an understanding of the dynamics of development of a corporate SDI because they will all draw on the spatial datasets from the CSDIs (CHAN, T. and I. WILLIAMSON, 1999).

A *local SDI* is generated at a sub-national level by cooperation between different companies, municipalities, or states in order to ease the access to and share of spatial data.

National spatial data infrastructures (NSDI) are established to navigate through the complexity of communications and relationships between states and agencies to achieve a common understanding of spatially related issues across a nation. This is paramount for the economy, management of the environment, social issues, security, etc. NSDIs are established to form a framework to share data across agencies and between disciplines to ensure that the users easily access and retrieve complete and consistent geospatial data. Furthermore it is an important basis for potential bilateral and multinational initiatives. (WILLIAMSON, I., A. RAJABIFARD, and M.E. FEENEY, 2003; MASSER, I., 2007)

*Regional SDI*s result from the imperative to seamlessly cooperate with other adjacent countries to assist in multinational and (sub-)regional decision-making across national boundaries (e.g. the INSPIRE initiative) (MUGGENHUBER, G., 2004; BERNHARD, L. ET AL., 2005; MASSER, I., 2005; EC, 2007b; MASSER, I., 2007). In 2006 still 60-80% of the working hours within the organisations of the European Union (EU) were used for acquisition and union of (spatial) data (MENGE, F., 2006).

A spatial data infrastructure at a global level (*GSDI*) aims primarily to link national and regional initiatives. A GSDI promotes a global open process for coordinating the organisation, management, and use of geospatial data and related activities. (WILLIAMSON, I., A. RAJABIFARD, and M.E. FEENEY, 2003; NEBERT, D., 2004)

Additionally Fig. 3 describes whether the product or process-based model suits the needs of the jurisdiction best. The organisational pyramid includes strategic, management, and operational levels which classify the different roles that people play within an organisation. At a global or regional level, SDI can be considered similar to the strategic tier of an organisational structure from which a process-based approach to SDI development is most appropriate. An NSDI has a resemblance to both managerial and strategic tiers, depending on the political system of the nation. The countries can select between SDI development models to optimise advantage. In some cases, a combined approach can offer most potential for developing effective NSDIs. Sub-national SDIs shall adopt the product-based approach to SDI development because most of the data collection and production as well as implementation activities occur at this sub-national level. Furthermore it facilitates national-wide communication and coordination of SDI development for the national government of the country through a process-based model. (RAJABIFARD, A. ET AL, 2006)

2.1.4 Advantages of SDI

The beneficiaries of an SDI affect the users and data producers/providers in equal measure. The literature points out the following advantages of an SDI for both sides (GROOT, R. and J. MCLAUGHLIN, 2000; RAJABIFARD, A. ET AL., 2000; CHAN, T. ET AL., 2001; LEHMANN, A. ET AL., 2002; RAJABIFARD, A. and I. WILLIAMSON, 2002; NEBERT, D. and K. LANCE, 2003; BLASER, F., 2004; MICUS, 2004; NEBERT, D., 2004; BERNHARD, L. ET AL., 2005; CLAUSEN, C. ET AL., 2006; KIEHLE, C., 2006; MASSER, I., 2007):

- *Data*: Spatial data is often collected several times by different agencies on project purpose in different accuracies and saved in different data formats. The increasing awareness of the value of spatial data and the rising of SDIs lead to the reduction or even prevention of unnecessary and expensive multiple data collection and facilitate multi-levelled spatial data integration. An SDI supports the geographic information sector to create data once and use it many times for many applications. Thus data users can save costs and put increased efforts in the development of new and innovative business applications instead of data collection.

- *Cooperation*: By establishing an SDI, partnerships between the various stakeholders, both users and producers of spatial data, will come into existence. These new partners will cooperate with each other and utilise technology in a cost-effective way to better achieve the objectives at the appropriate political/administrative level.
- *Policy*: The establishment and management of an SDI are based on long-term considerations and need the full involvement of the politicians/managers concerned at all costs. Politicians/managers need to be convinced of the improvement of (political) decisions and the support of sustainable economic, social, and environmental development by using easily accessible data. Additionally SDIs ease the possibility for decision-making across competencies and special fields. Moreover they facilitate knowledge building, communication, and knowledge transfer. SDIs are often the precondition to reach a market expansion.
- *Access*: An SDI enables a wide variety of users, who require coverage of a certain area covered by the SDI, to access and retrieve complete and consistent data sets at all scales in an easy and secure way. A fully functional SDI assures a quick and efficient access to the available spatial data for the user at a single contact point (e.g. web portal). These advantages will promote the reuse of the SDI, an ever-growing, readily available, and usable pool of spatial information provided by spatially and thematically distributed providers of data. The users will cash in on cost and time savings on data access.
- *Technology*: An SDI ensures the interaction with up-to-date technology, to better achieve the objects at different political levels. A more efficient development of services that are using existing data and standards and the provision of technologies for users are driving forces too. Only through common conventions and technical agreements the discovery, acquiring, exploitation, and sharing of information at all scales will be easily possible for all users.

- *Cost*: A fully established SDI reduces costs of data creation and maintenance and produces significant human and resource savings and returns. Moreover there will be an increase in efficiency and data quality. These financial advantages are of peculiar importance for investment decisions because the saving of time often leads to a competitive advantage. Quick and target-oriented information retrieval saves resources, effort, time, and costs for SDI users by the integration of datasets. Prices and licensing should not limit the availability and use of spatial data.

- *Interoperability*: Due to the utilisation of proprietary data formats and different spatial references, data collected by different organisations are often incompatible. The data may cover the same geographic area but use different geographic bases and standards. Information needed to solve cross-jurisdictional problems is often unavailable. De-facto standards or ISO-certified data formats shall be used because they are applicable by many users. Furthermore the spatial reference system of the data shall be made available and it shall base on international parameters. Identical data models facilitate the use of different spatial data sources. Interoperability ensures an enhanced data exchange between providers and users and a more efficient data usage. Moreover metadata are essential to provide knowledge about the type, location, quality, and ownership of spatial datasets and lead to a knowledge based infrastructure. Interoperability is the prerequisite for a working connection of spatial data services in processes inside an SDI.

2.1.5 Interoperability and the role of standards

The interoperability of systems and concepts is an important requirement for the implementation and handling of an SDI. Today there are several developers of standards at different levels whose deliverables have to be kept in mind and shall be used (GROOT, R. and J. MCLAUGHLIN, 2000; BERNHARD, L. ET AL., 2005):

- *National government agencies* are established in many countries with specific responsibility for all types of standards, including general and specific information system standards impacting geospatial data.

- *Independent standardisation organisations* work in a consensual building process to adopt and promote formal standards, including representations from government agencies, professional organisations, and private companies. Independent standardisation organisations have open policies for membership and formal committee structures and procedures for standards development, review, and approval (e.g. ISO, CEN (European Committee for Standardization)).

- *Industry consortia and trade associations* are formal or informal associations, with the mission for joint definition, development, and promotion of standard-based products (e.g. OGC).

- *Professional organisations* are established at different scales with different intentions. At the international level, ISO established a technical committee for Geographic Information (ISO/TC 211) that impacts SDI development and covers topics like data transfer, metadata, data classification, or data quality.

Different types of standards are impacting an SDI. On the one hand standards are covering detailed technical concerns to assure the interoperability of computer systems and provide the basic computing and infrastructure for system integration and information sharing, like hardware ore network communication standards. On the other hand database design, data format, data exchange and access, or representation topics (e.g. user interface) are harmonised (GROOT, R. and J. MCLAUGHLIN, 2000). Due to the variety of data providers, standardised data exchange formats for geographic information are essential. Basing on Extensible Markup Language (XML) the Geography Markup Language (GML) standard is established and is still enhanced to cover the needs for dynamic and time-based geographic information.

2.1.6 Implementation of a CSDI

A company can be regarded as spatially enabled when location and spatial information are regarded as common goods and made available to customers and businesses to encourage creativity and product development. The key challenge is how to develop a CSDI that will provide an enabling platform in a transparent manner that will serve the majority of staff who are not spatially aware. (MASSER, I. ET AL., 2007)

Realising this vision of spatially enabled company is dependent on the development of appropriate mechanisms and principles to facilitate the delivery of data and services. These principles comprise of a single data collection and maintenance, sharing and combination of seamlessly spatial data from different sources, missing restrictions in data use, the availability of metadata including source, availability, purpose, and conditions for its use, and the implementation of interoperability of spatial data (MASSER, I. ET AL., 2007). Interoperability complications shall not occur because of seamless and (spatially and thematic) matching spatial data (NEBERT, D., 2004).

The key drivers for the implementation of a CSDI are the expected increase in quality and efficiency. Furthermore economic and legislative reasons bring companies to establish an SDI. Above all the reputation for the company increases with implementation of an SDI. According to COLEMAN, D.J. ET AL. (1997) a clear strategy to implement a CSDI has to contain the following activities because an SDI does not develop in isolation:

- *Obtaining and maintaining corporate commitment*: Since it is a corporate strategy, a strong and sustained commitment in terms of financing, policies, and resources must be obtained. However, it is also important to convince the management at all levels of the need for the long-term investment in the CSDI in the early stages because of the feasibility and the value of the initiative (WILLIAMSON, I., A. RAJABIFARD, and S. ENEMARK, 2003). It has to be ensured that the issues are resolved through policy, legislation, regulation, agreements, or other means.

- *Evaluating requirements and implementation priorities:* The contribution of this multi-levelled, future-orientated research must be placed in perspective for CSDI participants and the management with major investments in the initial stages. After evaluating the requirements and current status the following step is to determine priorities.

- *Preparing Initial Metadata*: A(n) (online) tool is needed to index, retrieve, and summarise information on what exists where. Moreover this tool to incorporate access to metadata of a particular data set has to meet the needs of the user.

- *Involvement of all interested parties*: The initial task within the organisational arrangements is to define the role that all stakeholders play and their specific responsibilities within the CSDI.

- *Developing organisational structures*: A wide range of options for coordinating bodies and structures to initiate and manage the CSDI development should be investigated by reviewing examples from other CSDIs. The organisational structures should be able to evolve to accommodate the changing priorities and future needs of the CSDI development.

- *Developing standards and policies*: A continuation of current research and coordination initiatives are crucial in determining the databases that can be part of the infrastructure and in developing the information marketplace.

- *Developing and monitoring projects*: Building the CSDI has to involve internal and external projects specially designed for the CSDI. The management and monitoring of these projects is essential.

Once established, an SDI has often been assumed to remain static which limits the understanding of the nature and possibilities of SDIs as well as the optimisation of their potential and the capacity for their evolution. The dynamic and complexity of SDI fail to convey even in current perceptions and descriptions. Better descriptions of SDI's multi-dimensional capacity as an inter- and intrajurisdictional spatial information framework are required. (CHAN, T. ET AL., 2001)

An SDI can be regarded as successful, when clear benefits for the managers and users can be measured. A lack of barriers, the visibility of services and data, and an increase in data quality shall be achieved in an affordable way. The risks of SDI implementation rest in uncoordinated, divergent development, and rising costs. If the benefits of an SDI are not presented in an appropriate way, providers and users are losing faith in the usage.

2.1.7 SDI development and next generation

The major objectives of SDI initiatives in the first generation were to promote economic development, to stimulate better government, and to convey environmental sustainability. Within this first period, SDIs were designed and developed by countries based on their specific national characteristics, requirements, and priorities with the major outcome of documentation of experiences on SDI initiatives. In particular these initiatives were product-based approaches to SDI development led by data producers and national agencies. The key drivers were data production, database creation, and centralisation. (RAJABIFARD, A. ET AL., 2006) (Fig. 4)

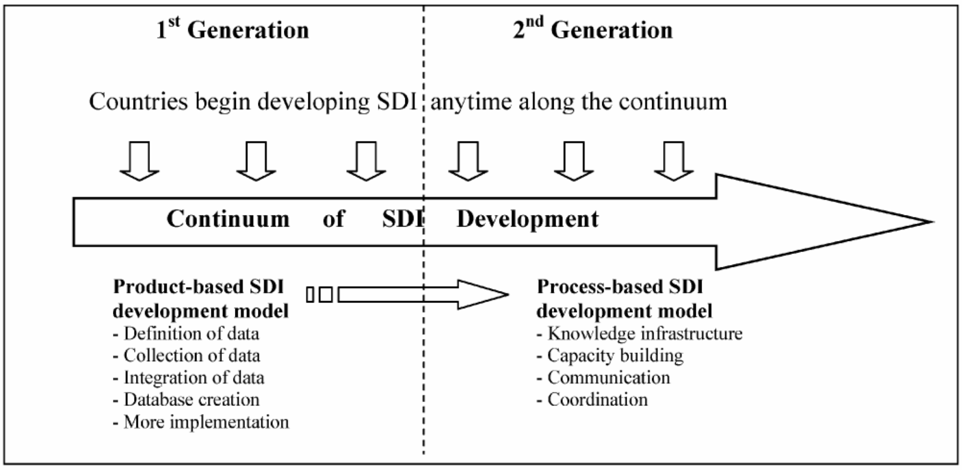

Fig. 4: Relationship between the first and second generation of SDI development and the product- and process-based SDI development models (RAJABIFARD, A. ET AL., 2006)

Around 2000 there started the transition to the second generation of SDI when the leading countries of SDI development changed their strategies and updated the SDI conceptual model. The rapid development of the internet promoted the shift to a much more user-oriented SDI concept with its focus on applications. Moreover a maximisation of the added value of a nation’s spatial information assets and cost-effectiveness were achieved. The main goal of the second generation of SDI aimed on the creation of an infrastructure to facilitate the management of information assets instead of the linkage to existing and future data sources. This process-based model is driven by data sharing and reusing of the multi-disciplinary and multi-scaled data which was collected during the first SDI generation. In addition there was a movement to decentralised and distributed networks that are a basic feature of the World Wide Web (WWW). (RAJABIFARD, A. ET AL., 2006) (Fig. 4)

In order to address current information requirements the role of the traditional SDI needs to be adjusted towards a service-oriented infrastructure on which citizens and organisations can rely for the provision of required services. These requirements go beyond current first- and second-generation SDIs focusing on data discovery and retrieval. This implies integration of all spatial datasets and the need for an SDI that facilitates this integration. The technology already exists, but there is the imperative of sustained input from both data producers and users. (RAJABIFARD, A. ET AL., 2006)

The increasing amount of knowledge gained by dynamic chaining of GI-services and the complete implementation of semantic interoperability must be integrated in future development for interdisciplinary reasons. Another focus must be laid on an improved and up-to-date availability of dynamic, spatio-temporal information to enable SDIs to be suitable backbones for decision support processes in temporal critical application areas. Furthermore authorization and authentication functionalities to secure multi-institutional operations through access control are needed. Multilingual metadata ease a global application. User interaction and the provision for the user needs are essential. Up-to-date technology shall be used without being the main driving factor. Finally networking remains the key to successful SDI development. (WYTZISK, A. and A. SLIWINSKI, 2004; CRAGLIA, M. ET AL., 2007)

In many respects SDIs are indifferent from other kinds of information infrastructure in their implementation and use. Thereby they face similar challenges. Consequently SDIs will become less distinctive from mainstream information technology and its spatial functionalities become an essential part of information infrastructure in general. The convergence of computing towards required open systems and interoperability may lessen the justification for a separate status of geospatial technologies. Still an SDI is providing an effective and efficient framework where a multitude of stakeholders with different expectations and interests is already involved. (MASSER, I., 2005; DE MAN, E., 2006; MASSER, I., 2007)

Finally the SDI concept has clearly entered the political arena and an increasing number of spatially enabled disciplines try to participate in and benefit from the network (e.g.

INSPIRE initiative). This reduces the danger of intellectual isolation and of reinventing the wheel of information technology (MASSER, I., 2007). Specialised tools will still be important to handle spatial data effectively and efficiently (DE MAN, E., 2006).

IAN MASSER (2005; 2007) summarised four key issues which play a vital role for the future of SDIs:

- *Governance*: There is the necessity to go beyond establishing the mechanics of SDI coordination and give top priority to the creation of appropriate SDI governance structures which are both understood and accepted. It is important that all stakeholders that are involved can develop a shared vision and feel a sense of common ownership. Although this may slow down things in the short term, is builds a base for future collaboration. This is an essential prerequisite for long-term success.
- *Facilitating access*: One of the biggest problems for the users is lack of metadata, although they can be developed easily. Without spatial portals and appropriate metadata services SDIs won't be accepted and used by the audience.
- *Building capacity*: SDIs succeed with the possibilities of their hierarchical availability. Often a change in organisation is needed for SDI development. Furthermore small or less-developed organisations or countries are limited to the implementation of SDIs.
- *Interoperability*: The development of SDI involves much more than database creation. Interoperability in terms of infrastructure, data model, data exchange, and data access must be achieved by using international standards.

2.1.8 Towards an aeronautical SDI

The current operational infrastructures of the ANSPs are very complex and often individually built. There is lack of interoperability, data sharing, and cooperative scheduling in the investment, planning, and management. Due to the awareness of resulting disadvantages the ANSPs are starting a transformation of their (spatial) data driven by the continuous progress in (computer) technologies. In 2007 S. VAN DER STRICHT and Å. STANDAR finally introduced at the Mini Global AIS (aeronautical information services) Congress the idea of SDI to the aeronautical community. An important first step in this transformation is to organise the corporate (spatial) data in an SDI. This is a difficult process because this SDI has to fit different scales. Usually an ANSP is a company which is in charge of the ATM for a state. So the establishment of a CSDI and a national (aeronautical) SDI has to be accomplished at the same time including all of their basic necessities and imperatives. Additionally attention should be paid to the future needs of the integration and provision of the spatial data of the ANSP in a regional (e.g. European) infrastructure. Till this day this fact has not yet regarded by the ANSPs. The INSPIRE initiative includes aeronautical data mainly as a part of the transport network and meteorological geographical features (weather conditions and their measurements (e.g. precipitation, temperature, evapotranspiration, wind speed and direction)) that are important and for air navigation (EC, 2007b).

The current EUROCONTROL programme, the EAD, does not fit to the idea of SDI or the INSPIRE initiative because it does not serve basic SDI needs. The antithetic conceptual design of the EAD bases on a single, centralised reference database of harmonised and quality-assured aeronautical information and, simultaneously, provides a fully integrated, state-of-the-art AIS solution (EUROCONTROL, 2008b). Dissenting votes of several European ANSPs note that a single, fixed data source offers no up-to-date solution but a distributed system, with a central authority for reconciliation. Furthermore the ANSPs impeach the credibility of a statement that a single database is more cost effective than a State solution although additional considerations concerning cross-border harmonisation are needed.

Contrary to the data-centric view of the EAD the ICAO started in cooperation with CANSO (Civil Air Navigation Services Organisation) in 2008 a net-centric approach for aeronautical information. ICAO recognizes that a robust, globally interconnected network in which information is shared in a timely and formal consistent way among users, applications, and platforms is more up-to-date. In addition this scheme is supported by the future directions of information technologies. Moreover a harmonisation with other regional aeronautical activities (e.g. NextGen) has to be a key driver for reasons of global interoperability and collaboration.

2.2 Aeronautical information management (AIM)

2.2.1 Introduction

The ICAO, a UN (United Nations) Specialized Agency, is the global environment for civil aviation. ICAO works to achieve its vision of safe, secure, and sustainable development of civil aviation through cooperation amongst its member states (ICAO, 1995a).

To implement this vision, ICAO has established the following strategic objectives for the period 2005-2010 (ICAO, 2004c):

- *Safety* - Enhance global civil aviation safety
- *Security* - Enhance global civil aviation security
- *Environmental Protection* - Minimize the adverse effect of global civil aviation on the environment
- *Efficiency* - Enhance the efficiency of aviation operations
- *Continuity* - Maintain the continuity of aviation operations
- *Rule of Law* - Strengthen law governing international civil aviation

According to these objectives international standards and recommended practices were established which the member states or the delegated ANSPs are obliged to comply. In order to fulfil the requirements of ICAO and in addition to prepare Europe for future tasks concerning ATM, the SESAR Consortium was created by the European Commission (EC) and EUROCONTROL (EC, 2005a; EC, 2005b).

The implementation of an SDI as a common (geospatial) data pool for AIS/AIM would be a small but very important piece of a puzzle to support the objectives mentioned. An aeronautical SDI would be a perfect match to the net-centric approaches by ICAO and CANSO too.

2.2.2 Definitions

Aeronautical information services (AIS) are established by an ANSP within a defined area of coverage responsible for the provision of aeronautical information or data necessary for safety, regularity, and efficiency of air navigation (ICAO, 2004b).

Aeronautical information are resulting from the assembly, analysis, and formatting of aeronautical data (ICAO, 2004b).

However *aeronautical data* are (geospatial) representations of aeronautical facts, concepts or instructions in a formalized manner, suitable for communication, interpretation and processing (ICAO, 2004b).

Aeronautical information and data of a lasting character essential to air navigation are published regularly using a standardised AIS product, the aeronautical information publication (AIP). The AIP, issued by or with the authority of a State, consists of textual descriptions and aeronautical charts (ICAO, 2001a; ICAO, 2004b). The AIP contains much information with spatial context because many characteristics in ATM have to be exactly located on or above the surface of the earth (e.g. obstacles, airways, runways, airspaces).

2.2.3 Demands on spatial data for AIS

Spatial data for AIS cannot be fully handled like “common” geospatial data. There are many international regulations that have to be kept in mind in order to distribute matching data to the customers.

ICAO delivers common reference systems, units of measurement, and requirements in temporality and data quality which an ANSP has to fulfil to be compliant with the regulations. This compliancy is the precondition to be permitted to provide AIS (ICAO, 1995b; ICAO, 2001a; ICAO, 2001b; ICAO, 2002; ICAO, 2004a; ICAO, 2004b).

Spatial data for AIS are classified as basic information with permanent or long duration character and are integrated in the "static data"-concept.

2.2.3.1 Reference systems

2.2.3.1.1 Horizontal reference system

The World Geodetic System – 1984 (WGS-84) is used as the geodetic reference system for international air navigation (ICAO, 1995b; ICAO, 2001a; ICAO, 2001b; ICAO, 2004a; ICAO, 2004b). In this regard ICAO published comprehensive guiding material to provide a common basis for all member states (ICAO, 2002).

2.2.3.1.2 Vertical reference system

In general, the mean sea level (MSL) datum is used as the vertical reference system for international civil aviation. The MSL datum gives the relationship of gravity related height (elevation) to a surface known as geoid. The geoid globally most closely approximates MSL (ICAO, 1995b; ICAO, 2001a; ICAO, 2001b; ICAO, 2004a; ICAO, 2004b). The Earth Gravitational Model – 1996 (EGM-96) is used by international air navigation as the global gravity model (ICAO, 2002).

2.2.3.1.3 Temporal reference system

The Gregorian calendar and Coordinated Universal Time (UTC) are used as the temporal reference system for international air navigation (ICAO, 1995b; ICAO, 2001a; ICAO, 2001b; ICAO, 2004a; ICAO, 2004b). This agreement is essential for the temporality concept in air navigation (chapter 2.2.3.3).

2.2.3.2 Units of measurement

ICAO Annex 5 specifies the units of measurement to be valid in air and ground operations in international air navigation. ICAO proposes the use of the standardised system of units of measurement based on the International System of Units (SI). Additionally there is the possibility to use non-SI units (ICAO, 1997). This causes a mixture in units of measurement with which AIM has to deal with. Many non-SI units are used since long time and it is not easy to abandon this habit.

Subsequent listing shows the definitions of the most important units of measurement for distances according to SI (ICAO, 1997):

- One *metre* (m) is defined as the distance travelled by light in a vacuum during 1/299792458 of a second.
- One *foot* (ft) equals the length to 0.3048 metre exactly.
- A *nautical mile* (NM) equals the length to 1852 metres exactly.
- A *knot* (kt) is the speed equal to 1 nautical mile per hour.

Since the very beginning of air navigation altitudes, elevations, and heights are specified in ft and distances of tracks between reporting points in NM. Due to political reasons only China and Russia switched to the SI units for this information. The currently used flight management systems (FMS) allow the pilot to switch easily between these units of measurement.

The following table lists alphabetically the common SI and non-SI units for spatial data in AIS (ICAO, 1997):

Quantity	**SI unit (primary unit) (symbol)**	**Non-SI (alternative unit) (symbol)**
Airspeed	km/h	kt
Altitude	m	ft
Area	m^2	-
Distance (long)	km	NM
Distance (short)	m	-
Elevation	m	ft
Height	m	ft
Latitude	° ` ``	-
Length	m	-
Longitude	° ` ``	-
(Plane) angle	°	-
Volume	m^3	-

Tab. 1: Units of measurement for spatial data in international air navigation according to ICAO Annex 5 (ICAO, 1997)

2.2.3.3 Temporality

The temporality concept of aeronautical data of a lasting character is called aeronautical information regulation and control (AIRAC). The AIRAC system regulates the coming into effect of innovation, withdrawal, or significant change of aeronautical information. These effective dates are defined to an interval of 28 days. The information notified therein shall not be changed further for at least another 28 days after the effective date, unless the circumstance notified is of a temporary nature and would not persist for the full period (ICAO, 2003; ICAO, 2004b). Aeronautical information to be notified at an AIRAC date is called amendment (AMDT) and is published in an analogue and/or digital way using the AIP.

Implementation dates diverging from AIRAC effective dates shall not be used for pre-planned operationally significant changes requiring cartographic work and/or for updating of navigation databases (ICAO, 2004b).

Nevertheless it is possible to publish important ad hoc or temporary restricted announcements. Notices to airmen (NOTAM) are distributed by means of telecommunication containing information concerning the establishment, condition, or change of any aeronautical information. This guarantees the timely knowledge which is essential to personnel concerned with flight operations. (ICAO, 2004b)

2.2.3.4 Data quality

In accordance with the ISO 9000 series of quality assurance standards quality is defined as the degree to which a set of inherent characteristics satisfies certain requirements of stated and implied needs (GG, 2001-2008; ICAO, 2001a; ICAO, 2001b; ICAO, 2002; ICAO, 2004b). Each ANSP has to establish a quality management system which coordinates activities to direct and control the organisation with regard to quality. This quality system shall provide users with the necessary assurance and confidence that distributed aeronautical information/data satisfy stated requirements for data quality. Data quality is the degree or level of confidence that the provided (geospatial) data meets the requirements of the data user in terms of accuracy, resolution and integrity. Based on the temporality concept data traceability by the use of appropriate procedures in every stage of data production or data modification process has to be assured (ICAO, 2004b).

The draft implementing rule on aeronautical data and information quality (ADQ) of the EC inherits the data quality requirements specified in ICAO Annex 15 for ANSPs and expands them to the data originators who supply the ANSP with data. Within the annexes of this rule aeronautical data concerning aerodromes, obstacles, terrain, and metadata are specified. Furthermore data exchange and data quality issues are framed. (EUROCONTROL, 2007)

2.2.3.4.1 Accuracy

Accuracy is defined as a degree of conformance between the estimated or measured value and the true value (GG, 2001-2008; ICAO, 2002; ICAO, 2004b). In international aviation accuracy demands are based on a 95% confidence level. The underlying statistical distribution is usually taken to be the circular normal distribution (ICAO, 2002).

Usually aeronautical data is very accurate. In this context aeronautical data can be divided in two distinct categories (ICAO, 2002):

- *Reference aeronautical data*: The accuracy requirement for reference data is absolute. The information is either correct or incorrect. Reference aeronautical data serve as a basis for evaluated aeronautical data and consist mostly of factual information like navigation aid identifiers and frequencies, way-point names, hours of operation, etc.

- *Evaluated aeronautical data*: The required degree of accuracy of evaluated data varies dependent upon the basis and the use to which the data are put. Evaluated aeronautical data include such as positional data, elevation, runway length, magnetic variation, etc.

2.2.3.4.2 Resolution

Resolution is defined as the number of units or digits to which measured or calculated values are expressed and used (GG, 2001-2008; ICAO, 2002; ICAO, 2004b). Resolution is the smallest possible partition that can be represented by the method employed to make the positional statement. It must be considered that the resolution must not affect the accuracy (ICAO, 2002).

Precision is the smallest difference that can be reliably distinguished by a measurement process or the degree of refinement (GG, 2001-2008; ICAO, 2002; ICAO, 2004b). This degree depends on the performance of an operation or the degree of perfection in the instruments or methods used when making measurements.

ICAO Annex 15 provides resolution demands for many (geospatial) aeronautical data (ICAO, 2004b).

2.2.3.4.3 Integrity

Integrity is defined as the degree of assurance that aeronautical data and its values have not been lost nor altered since the data origination or authorised amendment (ICAO, 2002; ICAO, 2004b). Data integrity must be maintained and traceable throughout the whole data process from survey to data application or to the next intended user by an unbroken trail. Aeronautical data integrity requirements are based upon the potential risk resulting from the corruption of data and upon the use to which the data item is put (ICAO, 2004b).

To minimise this risk metadata must be kept of all changes made, including data accuracy, data origin, details of changes made to data, reason for the data change, references associated with the data change, the source of the data change, the identity of the person making the change, and date of change (ICAO, 2002).

Today there are different methods of measuring the integrity of aeronautical data. Integrity regulations by ICAO are referring to electronic aeronautical data in transit only. Bigger challenges are posed at the use of analogous data or the everyday occurrence of media disruption.

Loss in integrity does not necessarily mean loss in accuracy. But there is no longer the possibility to prove that the data are accurate without further verification. The integrity requirements for data depend on purpose and usage of the aeronautical data. ICAO classifies data and their integrity level as follows (ICAO, 2001b; ICAO, 2002; ICAO, 2004b):

- *Critical data*: There is a high probability when using corrupted critical data that the continued safe flight and landing of an aircraft would be severely at risk with the potential of a catastrophe (e.g. runway threshold data which define the exact landing point). The integrity level for critical data is 1 $\times 10^{-8}$ because this data must ensure the overall process of aviation.

- *Essential data*: There is a low probability when using corrupted essential data that the continued safe flight and landing of an aircraft would be severely at risk with the potential of a catastrophe (e.g. position of en-route navigation aid). The integrity level for essential data is 1 $x10^{-5}$ because the data need to be accurate at the planning stage. Any subsequent corruption should have no impact on the safety.

- *Routine data*: There is a very low probability when using corrupted routine data that the continued safe flight and landing of an aircraft would be severely at risk with the potential of a catastrophe (e.g. flight information region (FIR) boundary points). The integrity level for routine data is 1 $x10^{-3}$ because these errors do not affect the navigation performance.

Aeronautical data quality requirements related to classification and data integrity are provided by ICAO. Moreover the protection of electronic aeronautical data while stored or in transit shall be totally monitored by a cyclic redundancy check (CRC) (ICAO, 2004b). However several methods of CRCs (24bit, 32bit) can be used by data receivers to confirm the correct and complete receipt, but it is not sufficient to define the data quality.

2.2.3.5 Spatial data types and examples

2.2.3.5.1 Scales and sources

The spectrum of spatial data in AIS ranges from data which cover the whole delegated area of an ANSP (e.g. terrain data) to the scale of aerodrome areas (e.g. position of aerodrome lightings). Spatial aeronautical data is provided by a broad field of data sources and applications with different unique requirements to data quality need (ICAO, 2002):

- *En-route data* consisting of surveyed positions of navigation aids and communication facilities are usually provided by the owner/operator (air traffic control (ATC)) of the equipment.

- *Data for instrument approach and departure* are normally determined by the ANSP responsible for the procedure. These calculated data are often based on technical facilities like navigation aids.

- The *surveyed positions* of thresholds, gates, or obstacles located at an aerodrome/heliport are usually provided by the owner or operator of the aerodrome/heliport.

- The *declared positions* of airspace divisions and restrictions are normally defined by state civil aviation or military authorities or other government bodies.

This diversity in scales, sources, and needs drove ICAO to implement – in a first step – the area concept for digital terrain and obstacle data (chapter 2.2.3.6).

2.2.3.5.2 Vector data

Spatial data for AIS have its seeds in cartography and aeronautical charts (ICAO, 1987; ICAO, 2001a). Currently these charts are designed using CAD (Computer-aided design)- or, few and far between, GIS-software (e.g. aerodrome charts/plans) because the international standardised appearance of the charts is rather simple in order to fetch its content at a glance. Aeronautical charting experts are used to vector data which usually eases the switching to spatial databases.

Vector data uses points and lines to model geographic objects. The objects are saved by 2D- or 3D-coordinates in a reference system. An ordered list of points and lines defines a line string. By closing the line string a polygon is created. So vector data are useful for objects with well defined borders. BILL, R. (1999) as well as LONGLEY, P. ET AL. (2005) differ the following occurrences of vector data:

- *Point*: A point is a 0-dimensional and map-reduced, multidimensional representation of a real world phenomena (e.g. centre of a navigation facility) or an artificial construct (e.g. aerodrome reference point (ARP)). Furthermore points can represent a sample of lines, polygons, volumes or grids (e.g. one instance of a pointgrid). In the context of aeronautical information data quality requirements of point data are concerning location and elevation (height). Usually the third dimension of a planar point, line or polygon is stored as an additional numerical attribute. This technique is called 2,5D-modelling. An important restriction of this commonly used method is that there is no possibility to model two z-values on one position. Nevertheless AIS needs this functionality in terms of obstacles. All fixed and mobile objects that are located on an area intended for surface movement of aircraft or that extend above a defined surface intended to protect aircraft in flight are defined by the elevation of the base point, where it is located, and by its height (ICAO, 2004b).

- *Line*: Lines are 1-dimensional and they represent elements with a length but no area (e.g. airways, runway centre line) or elements whose shape is too narrow because of the scale (e.g. runway, street, river). Additionally they are used to define the borders of objects that have an area (e.g. apron, taxiway). In the case of aeronautical information line strings are used which are not only connected by straight lines but also by arcs (e.g. instrument flight procedure).

- *Polygon/area*: Polygons are 2-dimensional and they represent elements with an area (e.g. holding area). Most geographic objects are saved as polygons in a GIS. Different automatic procedures exist to ensure that the polygon is closed which is essential for topology reasons and neighbourhood relations. Different concepts are used to avoid multiple storages of border data in order to minimise errors. Polygons which represent aeronautical information are not only connected by straight lines but also by arcs (e.g. airspace borders).

- *Volume*: Volumes are 3-dimensional and represent elements with a volume expansion (e.g. airspaces). In the case of aeronautical information volumes are usually saved as polygons which have two or more additional numerical attributes which contain the horizontal limits of the volume.

2.2.3.5.3 Raster data

Today the implementation of raster data for aeronautical applications is rather minor. Raster data are often used as background information when digitising new vector information in the CAD software.

With the spreading of GIS in the niche of aviation the applications for the usage of raster information are increasing. According to ICAO the ANSPs have to establish airport mapping data bases (AMDB) for each international aerodrome. Satellite images or digital orthophotos are useful "additional" data sources for related AIS. Currently raster data is mainly used in the field of aeronautical meteorology.

2.2.3.5.4 Grid

A grid is a regular or irregular raster of point data used to save and represent surfaces. A grid models the surface in 2,5D, which means, that the elevation values (z-value) are saved as an additional numerical attribute. Additionally there is the restriction for only one z-value for one location. In the case of aeronautical information it is used for digital elevation models (DEM) which are representations of terrain surface by continuous elevation values at all intersections of the defined grid, referenced to a common datum (BILL, R., 1999; LONGLEY, P. ET AL., 2005; ICAO, 2004b). A DEM is often based on photogrammetric analysis. The regular distance between the points flattens turning points that lie in between (e.g. mountain tops, terrain edges, river basins). To enhance a DEM there is the possibility to densify the pointgrid with additional data of these characteristic form lines and minor features. In general a DEM is easy to create, manage, and obtain because it is supported by every GIS-software.

2.2.3.6 The area concept for terrain and obstacle data

Since AIM has to deal with different scales and accuracies ICAO provided in 2007 the area concept for electronic terrain and obstacle data (eTOD) to satisfy different quality requirements that are necessary to accommodate air navigation systems or applications. Therefore the field of responsibility is divided in four coverage areas depending on purpose and use of the dataset (ICAO, 2004b):

- *Area 1 – The State:* Area 1 covers the entire territory of a state including the aerodrome/heliport areas.
- *Area 2 – The Terminal Control Area (TMA):* Area 2 covers the TMA of an aerodrome as published in the AIP or is limited to a 45km radius from the ARP

(whichever is smaller). At aerodromes where instrument flight rules (IFR) are published but no TMA is established, Area 2 shall be the area within a 45km radius from the ARP.

- *Area 3 – The Movement Area:* Area 3 is only used at IFR aerodromes and covers the area that extends from the edge(s) of the runway(s) to 90m from the runway centre line(s). Additionally all other parts of aerodrome movement area(s) (e.g. apron, taxiway) are covered 50m from the edge(s) of these defined area(s).

- *Area 4 – The Precision Approach Area:* Area 4 is restricted to those runways where precision approach Category II and III operations are established. The detailed terrain information is required by operators to assess the effect of terrain on decision height determination. The width of the area shall be 60m on either side of the runway centre line while the length shall be 900m from the runway threshold measured along the extended runway centre line.

The following tables summarise the numerical requirements of terrain and obstacle data for each area type (ICAO, 2004b):

	Area 1	**Area 2**	**Area 3**	**Area 4**
Post spacing	3 arc seconds (approx. 90m)	1 arc second (approx. 30m)	0.6 arc seconds (approx. 20m)	0.3 arc seconds (approx. 9m)
Vertical accuracy	30m	3m	0.5m	1m
Vertical resolution	1m	0.1m	0.01m	0.1m
Horizontal accuracy	50m	5m	0.5m	2.5m
Confidence level (1σ)	90%	90%	90%	90%
Data classification Integrity level	routine 1 x 10^{-3}	essential 1 x 10^{-5}	essential 1 x 10^{-5}	essential 1 x 10^{-5}
Maintenance period	as required	as required	as required	as required

Tab. 2: Numerical requirements of terrain data according to ICAO Annex 15 (ICAO, 2004b)

	Area 1	**Area 2**	**Area 3**
Vertical accuracy	30m	3m	0.5m
Vertical resolution	1m	0.1m	0.01m
Horizontal accuracy	50m	5m	0.5m
Confidence level (1σ)	90%	90%	90%
Data classification Integrity level	routine 1×10^{-3}	essential 1×10^{-5}	essential 1×10^{-5}
Maintenance period	as required	as required	as required

Tab. 3: Numerical requirements of obstacle data according to ICAO Annex 15 (ICAO, 2004b)

2.2.3.6.1 Current status

Because of the high requirements and immense costs, the chapter of Annex 15 concerning eTOD has been controversial take-up by the ANSPs. The data for the Areas 1 and 4 should have been available by November 2008 and the data for the Areas 2 and 3 should be available by November 2010. Since there are still discussions about this chapter none of the ANSPs met the deadlines. The ANSPs are searching for suggestive connections with other (SESAR) projects to decrease costs and increase the application spectrum (e.g. integration of Area 3 data within the AMDB project). (ICAO, 2004b; MILERIDGE, 2008)

2.2.4 From AIS to AIM

2.2.4.1 Status of aeronautical information today

The primary goal of ATM is safety in international air navigation because ATM operations are a complex interaction of dissimilar activities (REID, K., 2008). By now the capacity of the airports is a limiting factor and the ATS routes are crowded especially to important airports. Moreover the number of flights is expected to at least double by 2020 (SESAR CONSORTIUM, 2006a). Over the past decade ANSPs have coped with significant traffic growth in an acceptable safe and expeditious manner although ATM is working with infrastructures and techniques whose origins are going back to the 1950s to the 1970s (e.g. the use of radiotelegraphy for communication). Additionally the ATM decision processes are not automated for the most part (EC, 2005a).

Today the national infrastructures of ANSPs are complex and have low-levels of interoperability, limitations in data sharing, and there is a lack of cooperative scheduling in the investment, planning, and management of their assets (SESAR CONSORTIUM, 2006a; REDEBORN, B., 2007). The fragmentation of the European ATM network and the development of separate infrastructures cause substantial inefficiencies, a doubling of work, a multiplicity of costs, and a delay when introducing technical equipment on an international level. Increasing costs and decreasing performance are affecting the customers (EC, 2005a). There is currently no common architectural design of a European ATM system. The approach to standardisation must concentrate on service and functional performance based regulation (REID, K., 2008).

So far graphics and text have tended to be regarded as disconnected rather than complementary techniques for presentation of aeronautical information. This has been conditioned by the limitations of communications technology used in AIS (as instanced above in the comparison between NOTAM and AMDTs). In AIM, the frontier between text and graphics will dissolve. Only data of the required quality will be managed and made available. Moreover it will be up to the applications to choose, intelligently use, and – if required – display information in whichever format (textual or graphical) is the most appropriate and/or as requested by the user. Yet today the rapidly evolving GIS technology is expanding in AIS because it enables integration of graphical and textual data. A GIS supports the graphical and selectively layered presentation of geo-referenced aeronautical information (by geospatial co-ordinates). The concept of open systems architecture will enable ready interchange of data between systems, irrespective of their individual hardware or software specifications. (EUROCONTROL, 2006; REID, K., 2008)

With the increasing appearance of automation and the need for extracted and subsequently customised data for different systems (e.g. the FMS, user applications, etc.), the separate, product centric approach of AIS is no longer appropriate. AIS, as they are known today, have to be replaced by a data centric and system oriented solution, called AIM. Timely and reliable data for all phases of flight have to be made permanently and dynamically available for use in applications that perform the required tasks of any strategic or tactical

ATM activity. Thereby AIM will be responsible for both the content (including formats, timeliness, collection, checking, distribution, etc.) and the proper management of the data (storage, consistency between databases, interfacing with other systems, etc.). (EUROCONTROL, 2006; REID, K., 2008)

One key enabler of the ATM system is undoubtedly interoperability because it has to be the information itself that is of significance and not the technology that supports it. Nevertheless it is essential that the new definition of aeronautical data is provided in a common, system and platform independent format (or a set of harmonised formats). (EUROCONTROL, 2006; VAN DER STRICHT, S. and Å. STANDAR, 2007; REID, K., 2008; VAN DER STRICHT, S., 2008)

2.2.4.2 Exchange of aeronautical information

The exchange of aeronautical information with a lasting character can be arranged in different ways. First of all the ANSPs can do it directly either analogous or digital by ordering the AIP amendments. Secondly it is possible to use the EAD where all members of EUROCONTROL are able to store a predefined subset of their aeronautical data and other members are allowed to gather the data (EUROCONTROL, 2006; EUROCONTROL, 2008b). Unfortunately this kind of data exchange does not work well because of economic and political reasons.

Furthermore EUROCONTROL developed an exchange model for electronic data exchange to ensure that the data flow of aeronautical information keeps its quality, is efficient and cost effective, and supports real time (geospatial) information. Another goal of this model is to support the vision of a single global data source for data-centric operations. This would assure more accurate data as well as higher consistency as changes in the data automatically propagate through all AIS or AIM products. (EUROCONTROL, 2008a)

The aeronautical information exchange model (AIXM) is based on XML and is designed to enable the management and distribution of AIS data in digital format. The sophisticated temporary model (AIRAC and NOTAM), the ISO standards for spatial data including the use of GML, and the latest ICAO and user requirements shall be supported in the next release (Version 5.0) this summer. Furthermore modularity and extensibility is featured for current and future aeronautical information messaging and additional data attributing requirements. (EUROCONTROL, 2006; EUROCONTROL, 2008a; VAN DER STRICHT, S., 2008)

To accomplish the purposes of AIM a number of targeted data exchange models will be introduced dependent on the purposed usage of the data (Fig. 5). Based on AIXM these models are mainly intended for computer to computer exchange of aeronautical information. Currently different exchange models for weather information, airport mapping data, airport operation information, and terrain information are developed. (EUROCONTROL, 2006; VAN DER STRICHT, S. and Å. STANDAR, 2007; VAN DER STRICHT, S., 2008)

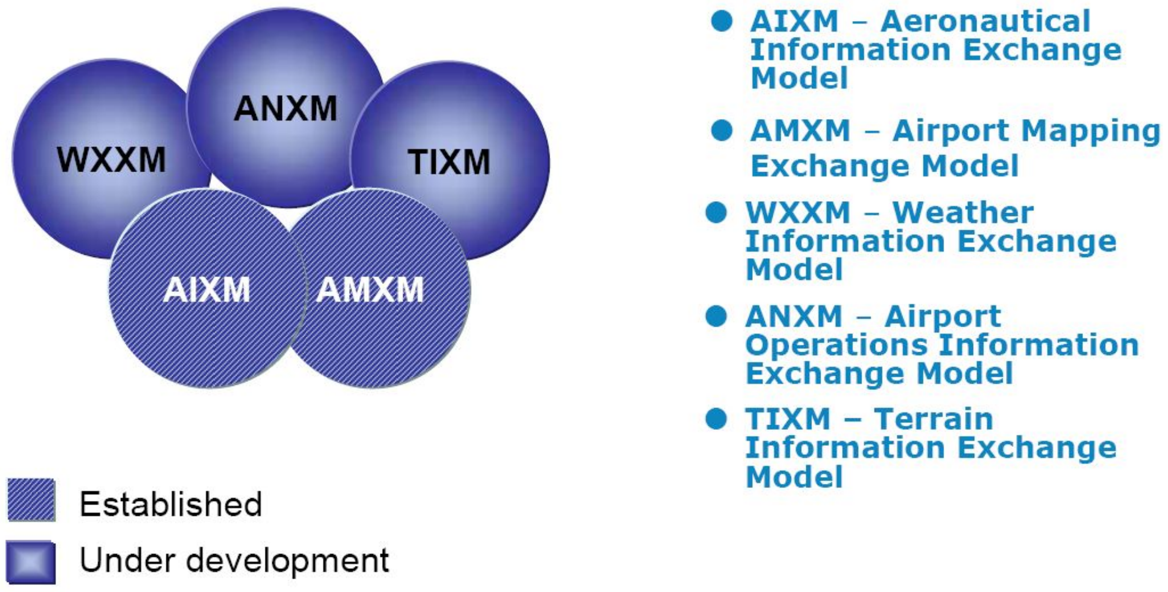

Fig. 5: The AIM concept in terms of exchange models (REID, K., 2008; VAN DER STRICHT, S., 2008)

Moreover AIXM 5 enables the provision of "digital NOTAM", where, in addition to the static information, the dynamic data also can be interpreted by the computer system (EUROCONTROL, 2008a). Basically, a digital NOTAM (xNOTAM) is “a data set made available through digital services containing information concerning the establishment, condition or change in any aeronautical facility, service, procedure or hazard, the timely knowledge of which is essential to systems and automated equipment used by personnel concerned with flight operations”. (EUROCONTROL, 2008c)

2.2.4.3 SESAR: the future of European ATM

The ICAO framework is still adequate for harmonising aviation globally, but the time period to develop and introduce its products is too long to meet the rapidly changing needs of the aviation business in Europe today. The delay of the introduction and use of technical innovation limits the flexibility of the whole European ATM system. The Single European Sky (SES) regulatory framework of the EC complements the ICAO framework and paves the way for a more commercial approach to be taken to providing air navigation services, whilst ensuring that safety remains the prime objective. (EC2005a; EC2005b; SESAR CONSORTIUM, 2006a; EC, 2007a)

SESAR is the European ATM modernisation programme and combines technological, economic, and regulatory aspects. It will use the SES legislation to synchronise the plans and actions of the different stakeholders and federate resources for the development and implementation of the required improvements throughout Europe, in both, airborne and ground systems. SESAR aims to establish the most modern, efficient, and secure ATM infrastructure of the world between 2020 and 2025 (EC2005a; EC2005b; EUROCONTROL, 2006; SESAR CONSORTIUM, 2006a; EC, 2007a; SESAR CONSORTIUM, 2008b). At the same time the USA is implementing their vision of a Next Generation Air Transport System (NextGen). The common vision of SESAR and NextGen is to integrate and implement new technologies to improve ATM performance. Both approaches combine increased automation with new procedures to achieve safety, economic, capacity, environmental, and security benefits. The established systems of SESAR and NextGen do not have to be identical, but must have aligned requirements for equipment standards and technical interoperability (REID, K., 2008).

There is a need for a paradigm shift in today's global concept of aeronautical operation to break through the "capacity barrier" predicted to occur around 2015. An increased use of automation to some tasks traditionally performed by humans has to be achieved. Modern data processing systems and communications protocols will be used, coupled with the trend to network multiple systems. Interoperability must be achieved at service and functional level throughout future ATM system through the development and convergence to a single functional architecture. All in all SESAR aims to increase safety by a factor of

10 by decreasing costs and environmental impacts. (SESAR CONSORTIUM, 2006a; SESAR CONSORTIUM, 2006b; REDEBORN, B., 2007; VAN DER STRICHT, S. and Å. STANDAR, 2007)

Present and future navigation are data dependent. Coeval higher quality and timeliness standards than today have to be reached. In consequence, the role and importance of digital aeronautical information is rapidly increasing (EUROCONTROL, 2006; REID, K., 2008). An evolution of AIM is needed, where the goal of AIM is the provision of the right digital aeronautical information, at the right place, at the right time. This includes the provision of information on-demand, information filtering based on location and time (4D), the fusion of static and dynamic information, seamless and interoperable information sharing, and innovation in digital services and products (REID, K., 2008; VAN DER STRICHT, S., 2008). A key concern of the AIM concept is service oriented architecture (SOA) which enables information sharing within the future ATM system. SOA is an architectural style which enables enterprise agility by using open and international standards (e.g. web services based on ISO/OGC-standards). This interoperability eases the adapting and enhancing of the system to evolving business needs. (VAN DER STRICHT, S., 2008)

2.2.4.4 SESAR and geospatial data

In order to reach the mentioned goals eleven initial indicative strategic design performance objectives and targets were defined. The following three performance targets are directly affecting geospatial data in AIM (SESAR CONSORTIUM, 2006b):

- *Cost-Effectiveness*: This key performance area covers the total direct gate-to-gate cost. The design of standard instrument departure (SID), standard arrival route (STAR), and instrument approach procedure (IAP) are based on the topographic conditions and on the obstacles in the sphere of influence. Up-to-date eTOD of high data quality, distributed via an effective organisation-wide infrastructure could already reduce ATM costs in the phase of planning.

- *Environmental Sustainability*: The aims of this key performance area are the management, control, and reduction of the impact of air traffic to the environment and to the people by atmospheric and noise emissions. An up-to-date spatial data set of high data quality is able to support this key performance area by using spatial analysis functions in the phase of (flight) planning, surveillance, and documentation. For instance, the noise cadastre established by the EU contains the measured noise emissions of aerodromes and the calculations of the impairment of the adjacent regions.

- *Interoperability*: Aeronautical information are of global nature and transcendent all national and regional boundaries. This key performance area aims at the application of global standards together with the technical and operational interoperability. This performance target is essential for geospatial data in terms of data integration, processing and distribution. The usage of the ISO 19000 series of geographic information and the technical concept of SDI in different scales are essential (VAN DER STRICHT, S. and Å. STANDAR, 2007).

In accordance to the performance targets, several target concepts are developed. A system wide information management (SWIM) is proposed where all ATM related data should be stored and provided to all ATM actors (EUROCONTROL, 2006; SESAR CONSORTIUM, 2007). SWIM is designed as a global, distributed aeronautical data management environment, managing aeronautical information (format, timeliness, collection, checking, distribution, etc.) as well as technical fundamentals (storage, consistency of data bases, global interfacing, etc.) (EUROCONTROL, 2006; REID, K., 2008). Due to the fact that the majority of air navigation data has a spatial dimension, a spatially enabled information management system should be used for the different information domains (e.g. flight information, meteorological information). Each information domain would be separated from the other domains for maintenance but linked when it comes to data request and usage. The main purpose of AIM is to support all other information domains as a common spatial basis (SESAR CONSORTIUM, 2007).

From 2008 up to 2013 the timeframe for SESAR states the creation of the foundations for the spatially enabled applications mentioned above concerning an increased information sharing and environmentally sustainable performance-based operations. The implementation of SWIM shall introduce dynamic information sharing to air navigation (SESAR CONSORTIUM, 2008a). The SESAR work programme is supported by an extended research and development programme where all member states are able to introduce new architectures and infrastructures like SDIs to the targets of SESAR (SESAR CONSORTIUM, 2008c).

In order to properly manage the development phase of this huge and ambitious project, a legal entity was created in 2007: The SESAR Joint Undertaking. The aim of the Joint Undertaking is to ensure the modernisation of the European ATM system by federating research and development efforts. Furthermore it will organise and coordinate the development activities of the SESAR project, in accordance with the ATM Master Plan. (SESAR CONSORTIUM, 2008c)

2.2.4.5 Conclusion

In a nutshell, an SDI could provide solutions for many requirements of SESAR because of its power in interoperability, scalability, and seamless transition. So far the SDI-concepts are not taken into consideration by AIM and SESAR. Moreover it is important that SESAR deals with the INSPIRE subject and derives advantage from its integration. It would be an inconceivable benefit for the aviation industry to abandon its narrow perspective concerning solutions for aviation solely.

3 Aeronautical information in the context of INSPIRE

3.1 Initial situation

NSDIs are established to share geospatial data at a national level and to provide a common basis to authorities and other users to answer different kind of problems. Aeronautical information has to be a part of this NSDI concept. According to K.U.LEUVEN (2008) no NSDI existed in Austria until 2007. Only concepts concerning metadata were established partially. Due to the fact that in the first stage of INSPIRE environmental needs are addressed primarily (EC, 2007b; EC, 2008b), finally the Umweltbundesamt - the expert authority of the federal government in Austria for environmental protection and environmental control - was assigned to establish an NSDI based on the INSPIRE directive. Therefore aeronautical information is assigned to the transport network spatial data theme. Additionally the Austrian NSDI concept lists obstacles pertinent for aviation as a separate data theme which are disregarded by the INSPIRE initiative.

The latest review of the INSPIRE draft shows that the data model concerning air transport needs some improvement and essential information are missing to meet the demands of AIM. This thesis offers an approach to the problem concerning the usage of INSPIRE as a European SDI (ESDI) framework for AIM. First an overview of INSPIRE and its specification language (UML) is given followed by a review of the draft on air transport network in particular. Based on this review an improved data model specification using UML is introduced in chapter 4 that serves the needs of AIM.

3.2 INSPIRE

INSPIRE is a directive of the EC to establish an infrastructure for spatial information in the European Community. Spatial information is needed for the formulation and implementation of the Community policy on the environment and other Community policies for transnational aspects in an integrated way, taking into account regional and local differences. (EC, 2007b)

Today various problems exist regarding the availability, quality, organisation, accessibility, and sharing of spatial information. They are common to a large number of policy and information themes and are experienced across various levels of public authority. Measures addressing exchange, sharing, access, and use of interoperable spatial data and spatial data services across the various levels of public authority and different sectors could solve these problems. Therefore a spatial data infrastructure at a European level should be established to assist policy-making in relation to policies and activities that may have a direct or indirect impact on the environment. (EC, 2007b)

The basis for INSPIRE should be the NSDIs of each Member State of the European Union adjusted for the European level, supporting the re-use of public sector information. This should ensure that spatial data are stored, made available, and maintained at the most appropriate level (diverging to the ideas of EAD). Moreover it should be possible to combine spatial data from different sources across the EU in a consistent way and share them between several applications and users. Spatial data collected at one level of public authority should be shared between other public authorities conveying their extensive use. Furthermore it should be easy to discover available spatial data, to evaluate their suitability for the purpose and to identify the conditions applicable to their use. (EC, 2007b; EC, 2008b)

INSPIRE should result in public access to environmental information, the re-use of public sector information, and the provision of an interoperable framework that builds upon existing experience and initiatives rather than duplicate the work that has already been done. Instead of setting requirements for the collection of new data INSPIRE should apply to spatial data held by or on behalf of public authorities and to the use of spatial data by public authorities in the performance of their public tasks. (EC, 2007b)

The Member States shall provide descriptions of available spatial data sets and services in the form of metadata for the spatial data themes. Access to their infrastructures should be provided through a Community geoportal, a network service operated by the Commission, as well as through any access points they themselves decide to operate. (EC, 2007b; EC, 2008b)

The directive specifies 34 different spatial data themes that should be included in the final stage of expansion of the ESDI in 2012. Aeronautical information can be found in the spatial data theme “Transport Networks” where road, rail, water, and air transport networks and related infrastructure are defined. Finally an integrated transport network should emerge seamlessly at a European level in order to additionally reflect the transport flow. The main links and overlaps of the transport network are supposed with the spatial data themes of hydrography, addresses, and land use. (EC, 2007b; INSPIRE, 2008a; INSPIRE, 2008b)

The spatial data themes used in the INSPIRE directive are specified in UML.

3.3 Unified Modeling Language (UML)

3.3.1 Definition of UML

UML is a standardized language for the specification, visualization, construction, and documentation of models for software systems, business models, and other non-software systems. In the sense of a language the UML defines thereby designators for most terms, which are important for the modelling, and specifies possible relations between these terms. Furthermore UML defines graphic notations for these terms, for models of static structures, and of dynamic operational sequence, which one can formulate with these terms. It offers the possibility to the developers of discussing the draft and the development of software models on uniform basis. UML diagrams do not represent an implementation, but only a general view on the object models. The notation of UML is programming language and software independent. (GRÄSSLE, P. ET AL., 2007; OMG, 2007; DUMKE, R., 2008)

This thesis uses notations in the current UML version 2.1.2, as published by the Object Management Group (OMG) in February 2007 (OMG, 2007).

3.3.2 UML class diagram

For the specification and visualization of the requirements of the data model for an SDI class diagrams serve. A class diagram in the UML is a type of static structure diagram. UML class diagrams describe objects, their characteristics - thus attributes and methods - and relationships between objects including inheritance, aggregation, and association. (GRÄSSLE, P. ET AL., 2007; OMG, 2007; DUMKE, R., 2008)

A class is a representation of an object and it is a template from which objects are created. Classes can be depicted as boxes with three sections (GRÄSSLE, P. ET AL., 2007; OMG, 2007; DUMKE, R., 2008):

- The top section indicates the name of the class.

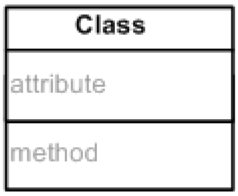

Fig. 6: UML conceptual class diagram: class

- The middle one lists the attributes of the class. Attributes are information stored about an object. Attributes can be derived from other attributes (e.g. the flight time can be derived from the departure time and the arrival time of an aeroplane).

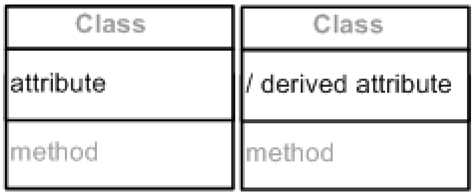

Fig. 7: UML conceptual class diagram: attribute and derived attribute

- The third section lists the methods. Methods are the things an object or class can do. This specification is often skipped during specification phase and it is not taken into account in this thesis either.

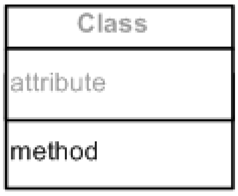

Fig. 8: UML conceptual class diagram: method

The following illustrations explain the graphical notation of relationships between class diagrams (GRÄSSLE, P. ET AL., 2007; OMG, 2007; DUMKE, R., 2008):

- *Generalisation* (implementation inheritance) characterizes a relationship between two classes, a general one and a special one. The special class is derived from the base class and extends the base class with additional (or modified) properties.

Fig. 9: UML conceptual class diagram: generalisation

- An a*ssociation* characterizes a bidirectional relationship between two classes. The relationship of objects of one class to the objects of another class conveys an exactly defined certain meaning. The relationship has to be labelled correspondingly (e.g. uses) and signed with a black triangle.

Fig. 10: UML conceptual class diagram: association

- The *multiplicity* defines the number of objects which are concerned with the association. The feasible multiplicity indicators are listed in Tab. 4.

Fig. 11: UML conceptual class diagram: multiplicity

Indicator	Meaning
0..1	Zero to one
1	One only
0..*	Zero to more
1..*	One to more
n	Only n (where n > 1)
0..n	Zero to n (where n > 1)
1..n	One to n (where n > 1)

Tab. 4: Multiplicity indicators in UML

- The *aggregation* is a particular case of an association with the special meaning “composed of” and is signed by a rhombus. An additional labelling in not necessary.

Fig. 12: UML conceptual class diagram: aggregation

3.3.3 UML package diagram

A package diagram depicts the dependencies between the packages (classes) that make up a model. Package diagrams can be used to illustrate the layered architecture of a data model. The dependencies between these packages can be marked with labels / stereotypes to indicate the communication mechanism between the layers. (GRÄSSLE, P. ET AL., 2007; OMG, 2007; DUMKE, R., 2008)

The following illustrations explain the graphical notations of a package diagram and the dependencies between packages (GRÄSSLE, P. ET AL., 2007; OMG, 2007; DUMKE, R., 2008):

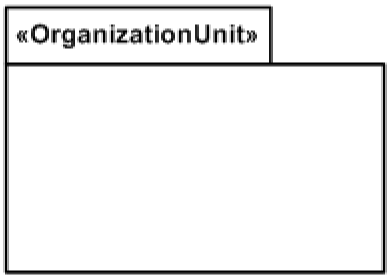

Fig. 13: UML conceptual package diagram: package

There are two special types of dependencies defined between packages:

- A *package import* is "a relationship between an importing namespace and a package, indicating that the importing namespace adds the names of the members of the package to its own namespace" (OMG, 2007). If a dependency between two packages is unlabeled it is interpreted as a package import relationship.

Fig. 14: UML conceptual package diagram: package import

- A *package merge* is "a directed relationship between two packages that indicates that the contents of the two packages are to be combined. It is very similar to Generalization in the sense that the source element conceptually adds the characteristics of the target element to its own characteristics resulting in an element that combines the characteristics of both" (OMG, 2007).

Fig. 15: UML conceptual package diagram: package merge

3.4 INSPIRE Data Specification on Transport Networks – Draft Guidelines

3.4.1 Scope

The purpose of the INSPIRE Data Specification on Transport Networks, published in December 2008, is to define a harmonised data specification for the spatial data theme Transport Networks as described in Annex I of the INSPIRE directive. Finally an integrated transport network including related features shall be established, seamless and scalable within each national border and at European level. Topological links between the four different sections road, rail, water, and air have to be established to support many different applications. (EC, 2007b; INSPIRE, 2008b)

According to the INSPIRE Thematic Working Group the key characteristics of the transport networks datasets are (INSPIRE, 2008b):

- The datasets contain information of specific interest for the extensive public sector in its role to support economic growth through efficient transportation, passenger safety, environmental impacts, etc.
- The information is applicable from local to European levels of operation and supports cross border (pan-European) applications.
- The data represent a structure or methods of operation that is stable over a specific period of time even though (parts of) the data content frequently changes.
- Being a part of the interoperable ESDI the spatial data may be more easily linked to related data themes.

3.4.2 Definitions

The most important definitions used by the INSPIRE draft and accordingly in this work are summarised in this section (INSPIRE, 2008b):

An *application schema* is defined in the Generic Network Model (GNM) of INSPIRE and meets a conceptual schema for data required by one or more applications. In UML a package diagram is used to describe it.

A *feature type* corresponds to a spatial object type, a classification for spatial objects. In UML a class diagram is used to describe it.

An *enumeration* is a fixed list of valid identifiers of named literal values. Attributes of an enumerated type may only take values from this list that is described in a UML class diagram.

A *code list* is a flexible enumeration that uses string values for expressing a list of potential values. A code list is an open enumeration that can be extended during system runtime and is described in a UML class diagram.

The attribute characteristic *«voidable»* describes that a spatial object does not have to be present in the spatial data set, but may be present or applicable in the real world. Voidable means on the one hand that this characteristic is not existing in the real world (e.g. there is no repairing facility on a small heliport) or on the other hand that there is no essential need that this attribute is filled in (e.g. the served city of an aerodrome).

3.4.3 Structure and dependencies

An overview of the structure and dependencies of the Data Specification on Transport Networks is shown in the following UML package diagram (Fig. 16). The Common Transport Elements application schema covers elements that are shared by the four different subthemes road, rail, water, and air. Due to diverging needs these subthemes are modelled as separate application schemas within the Transport Networks theme. (INSPIRE, 2008b)

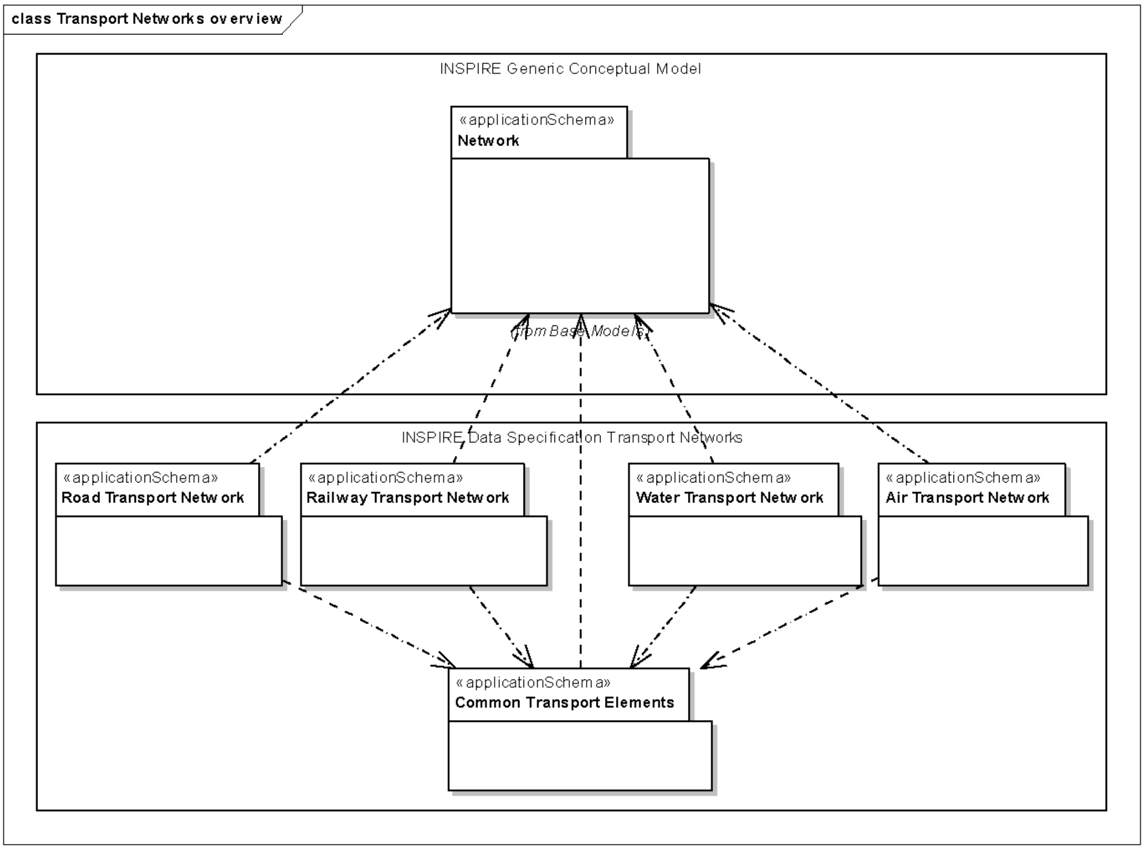

Fig. 16: Overview of Transport Networks UML structure and dependencies (INSPIRE, 2008b)

The Common Transport Elements are containing specializations of common definitions for networks and network elements available in the INSPIRE GNM. Network elements are handled as nodes, links, aggregated links, and areas. Connectivity between elements in different networks is included. (INSPIRE, 2008b)

The geometric basis of the transport network consists of a number of topologically connected linear elements (links) with point elements (nodes) at the ends of the lines (at junctions, terminals, etc). Links are combined to form AggregatedTransportLinks, using the mechanism provided by the GNM. Aggregated links have no geometry of their own but their position is defined by the composing links (Fig. 17). (INSPIRE, 2008b)

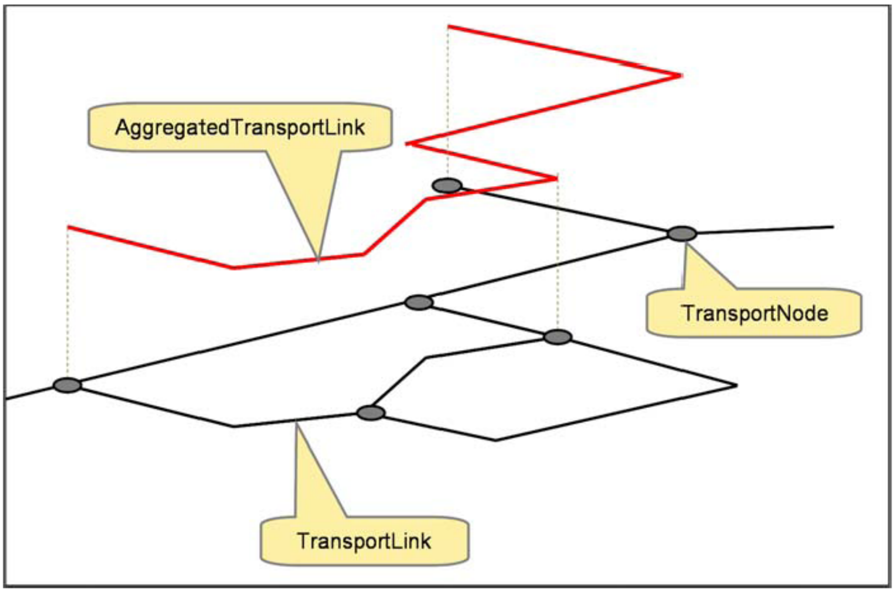

Fig. 17: Geometric representation of the link and node structure and the concept of the AggregatedLink (INSPIRE, 2008b)

Geometric, logical, and semantic consistency between spatial data sets has to be ensured including (INSPIRE, 2008b):

- coherence between spatial objects of the same theme at different levels of detail,
- coherence between different spatial objects within a same area, and
- coherence at state boundaries.

3.4.4 Draft review

The main focus of the air transport networks schema is to represent the air routes used for transportation in the form of a linear network using a link and node structure. It inherits classes from the common transport schema and also creates its own classes to describe properties of the air network.

According to the draft the presented feature catalogue should be able to support fields of application like asset management, capacity planning, construction, design and planning, disaster management, emergency response, environmental impact assessments, estate management, flow modelling, incident management, journey planning, maintenance, navigation, network operation, rerouting and diversions, routing, traffic control, and traffic management (INSPIRE, 2008b).

3.4.4.1 Topology

The topology concept of the draft guidelines of the INSPIRE Data Specification on Air Transport Networks is presented in the following figure (Fig. 18):

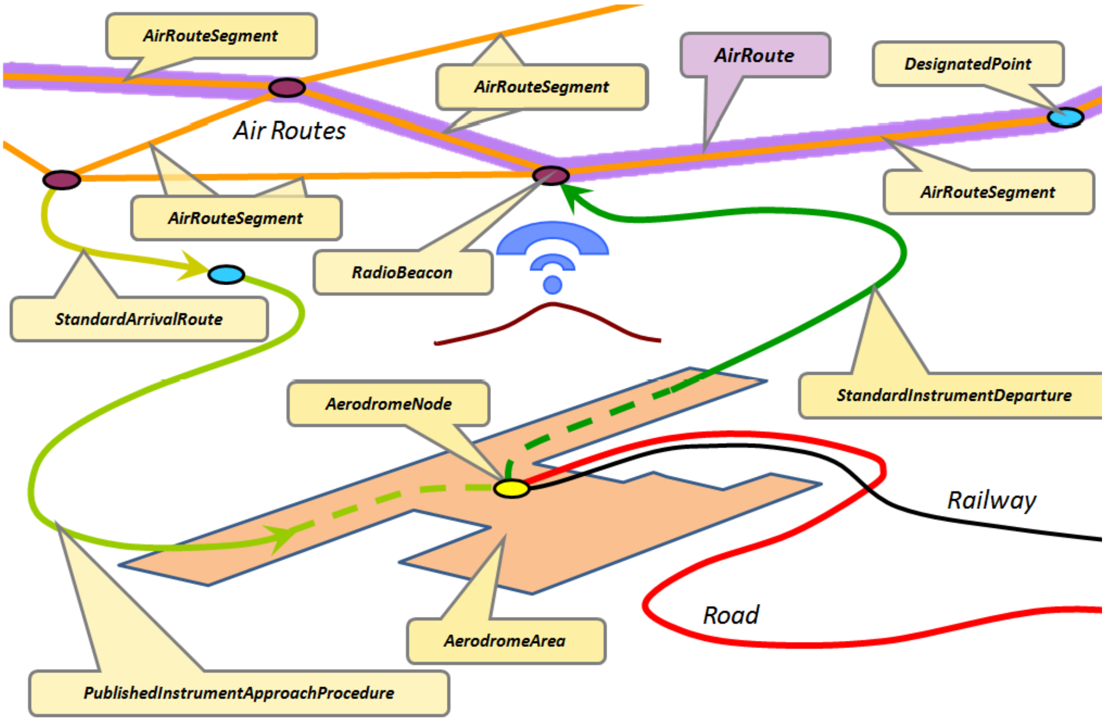

Fig. 18: Overview of the main air transport network objects and their topology (INSPIRE, 2008b)

In general the topology concept of INSPIRE is suitable for AIM except the linkage of the air routes to the ground as well as between different thematic subthemes. The aerodrome node, which equals the ARP, is used to join the aerodrome and the transport links. Furthermore it serves as the connector to the other transport networks like roads or rail. Moreover it currently serves as the connection point of SID and IAP to the ground. This does not make sense due to the fact that the ARP is usually located near the initial or planned geometric centre of the aerodrome area and is normally remaining where originally established. Additionally there is no need that the ARP is situated on paved ground or on the runway (e.g. Vienna International Airport). The sequitur is a relevant distortion of the transport network where other transport networks join the air traffic (Fig.

18). In the case of Vienna International Airport the linear distance between the locations of the train station (shown by train symbol along the dark railroad) or the street (shown by car symbol) to the ARP (shown by pin symbol; coordinates N48°06’37’’, E016°34’11’’south of the runway 11/29) is approximate 1.2 kilometres (Fig. 19). The red dashed line marks the possible course of the railroad when using the ARP for connectivity.

The fields of application of route and journey planning are theoretically still working when using the current concept, but the results concerning distances and journey time would be not accurate anymore.

Fig. 19: ARP vs. train station at Vienna International Airport (shown with Google Earth)

3.4.4.2 Node features

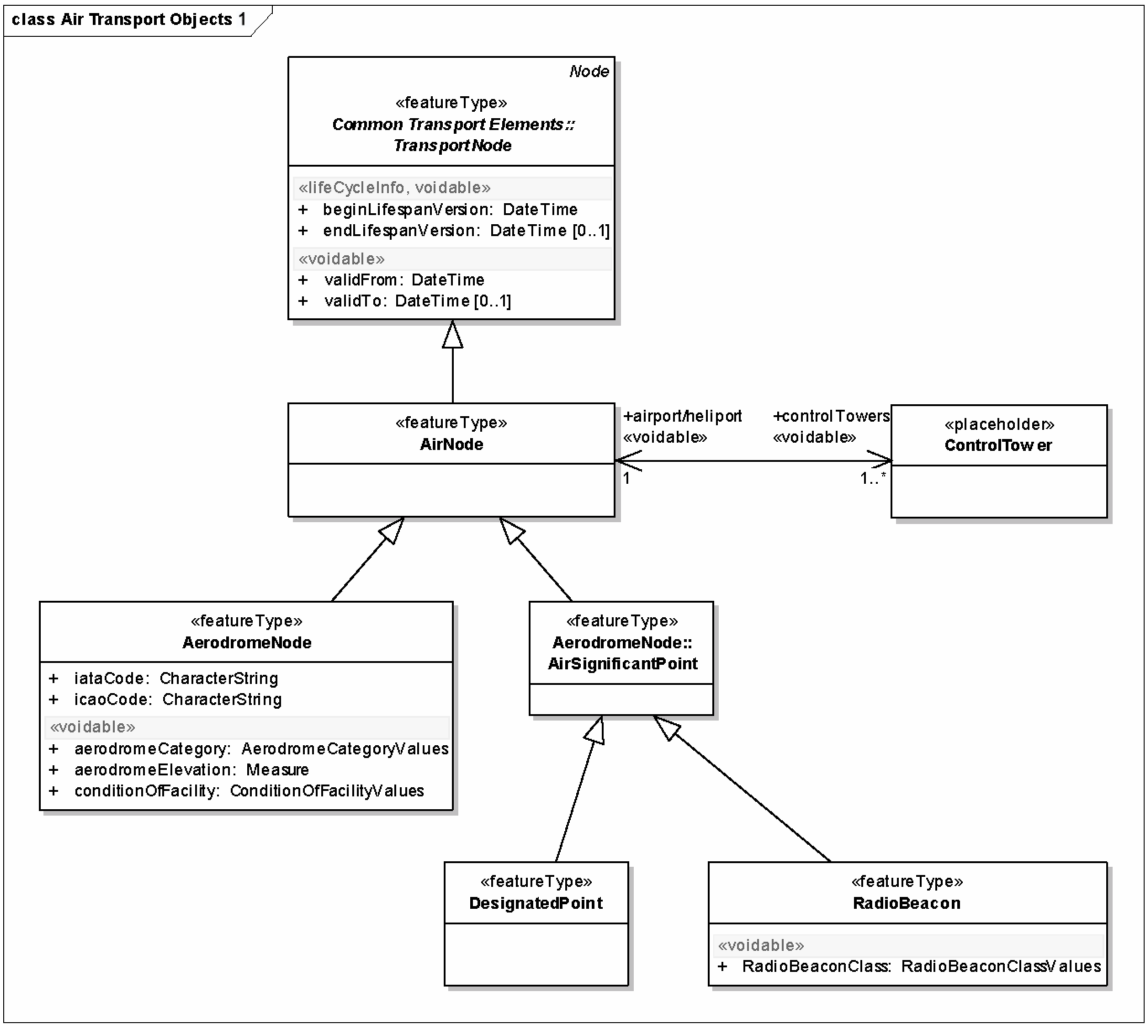

Fig. 20: UML class diagram: INSPIRE air transport network feature types, part 1 (INSPIRE, 2008b)

The draft guidelines of the INSPIRE Data Specification on Air Transport Networks define one subtype of the Common Transport Element Transport Node (Fig. 20):

- The *air node* is a point in the air transport network. Air nodes are divided in the aerodrome node including aerodrome information and the air significant point with its subtypes the navaids and the significant points of the route network. But how are – for instance – the fields of application of construction or design and planning supported if there is no detailed information concerning infrastructure at the aerodrome and obstacle information is missing completely?

3.4.4.3 Link features

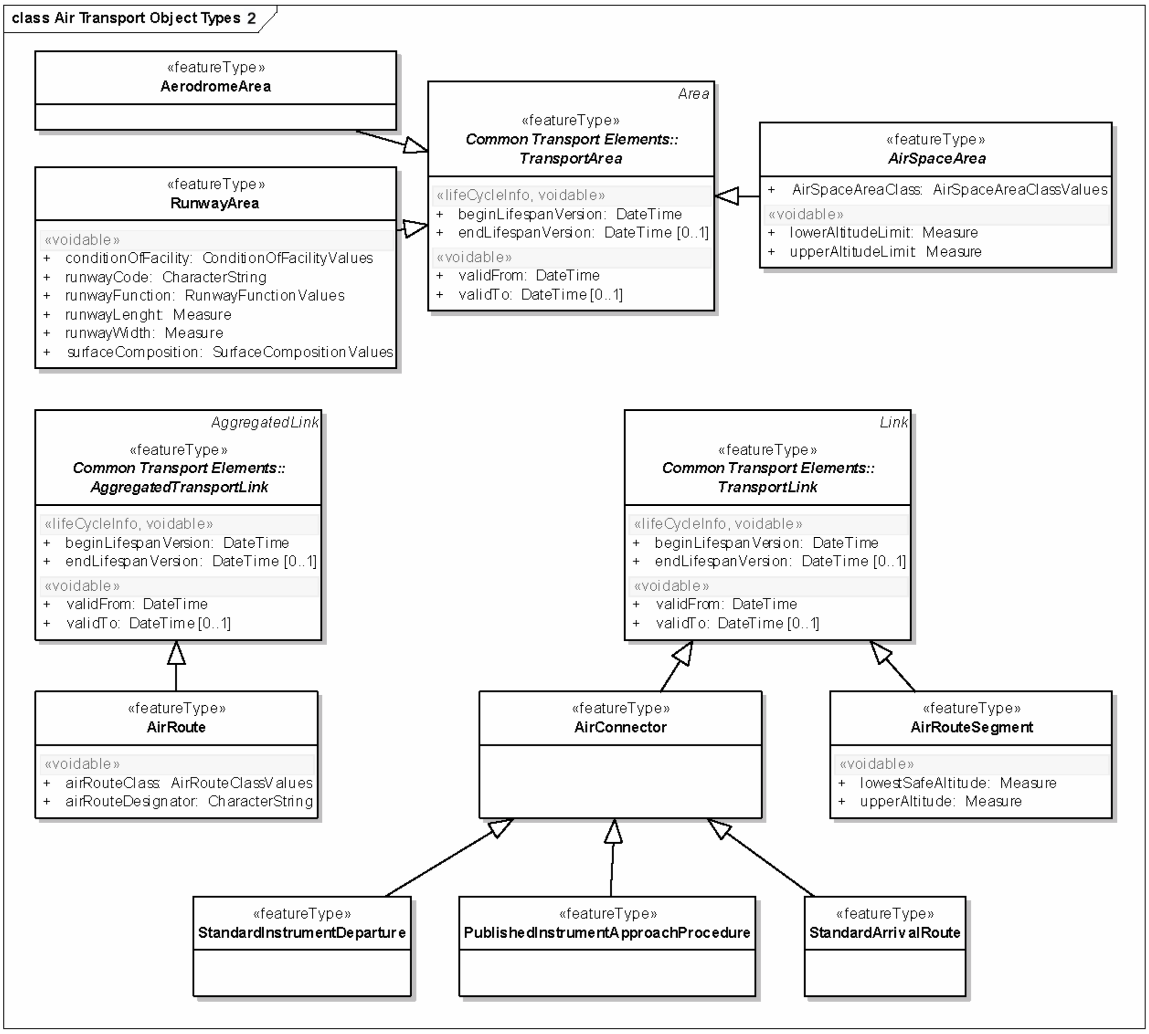

Fig. 21: UML class diagram: INSPIRE air transport network feature types, part 2 (INSPIRE, 2008b)

The draft guidelines of the INSPIRE Data Specification on Air Transport Networks define two subtypes of the Common Transport Element Transport Link (Fig. 21):

- The *air connector* is defined as the (fictitious) link between the aerodrome and the air route system. But how are – for instance – the fields of application of environmental impact assessment, traffic control, or traffic management supported if there is no detailed information concerning this connector (e.g. climb angle, missed approach point)?

- The *air route segment* represents a portion of a route defined by two consecutive significant points. But how are – for instance – the fields of application of routing or capacity planning supported if there is no information concerning the flight direction or the maximum speed?

3.4.4.4 Aggregated link features

The draft guidelines of the INSPIRE Data Specification on Air Transport Networks define one subtype of the Common Transport Element Aggregated Transport Link (Fig. 21):

- The *air route* is defined as an ordered collection of air route segments defining an air route, which usually is characterized by one or more thematic identifiers and/or properties. But how are – for instance – the fields of application of routing or capacity planning supported if detailed information concerning departure or arrival routes is missing and VFR (visual flight rules) traffic is left out completely?

3.4.4.5 Area features

The draft guidelines of the INSPIRE Data Specification on Air Transport Networks define three subtypes of the Common Transport Element Transport Area (Fig. 21):

- The *aerodrome area* consists of the topographical limits of the facilities of an inland aerodrome but there is no information concerning its segmentation or current infrastructures included. But how are – for instance – the fields of application of construction, design and planning, or capacity planning supported if this information is missing?

- The *airspace area* represents the airspace managed by ATC providing ATS for safe (IFR) navigation of aircraft. The only information concerning the airspace area supported by the draft is the airspace type and the vertical limits of the airspace. But how are – for instance – the fields of application of traffic control or traffic management supported if the airspace class information is missing where the tasks of ATC are defined?

- The *runway area* should represent the topographical limits of the runways used for aircraft traffic in an inland aerodrome for different purposes, such as landing, take-off, taxiing, and parking. But how are – for instance – the fields of application of disaster management or traffic control supported if runway functions like clearway, stopway, and the landing distances available are missing? (Moreover there are inconsistencies in the referencing of definitions to different versions of AIXM.)

3.4.4.6 Enumerations and code lists

The used enumerations and code lists of the draft guidelines of the INSPIRE Data Specification on Air Transport Networks are based on the limited scale of the draft. Due to the specification of INSPIRE an enumeration is a data type whose instances form a fixed list of named literal values whereas code lists are an open enumeration that can be extended during system runtime (INSPIRE, 2008c).

In the available draft some enumerations and code lists are incomplete (Fig. 22). For instance in the enumeration of the RunwayFunctionValues the clearway and the taxiway are missing and there would be no possibility to integrate these functional types in future. The code list of the airspace class values comprises only ten airspace types although there are at least more than twenty used in Europe. But in this case an enlargement of the list could be done.

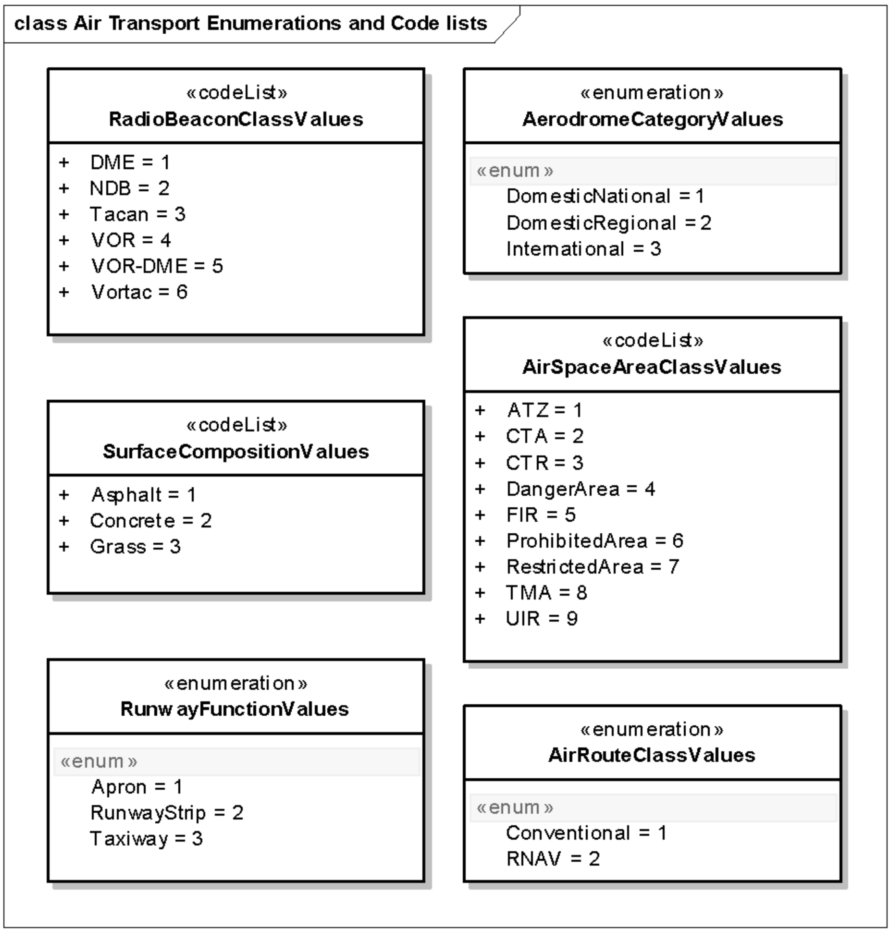

Fig. 22: UML class diagram: INSPIRE Enumerations and code lists (INSPIRE, 2008b)

3.4.5 Conclusion

The review of the draft guidelines of the INSPIRE Data Specification on Transport Networks shows that the data model concerning air transport needs some improvement and essential information is missing to meet the demands of environmental issues and AIM. Lack of information leads to problems in using the data model for considered fields of application.

The following chapter tries to solve the problems stated above.

4 Implementation

4.1 General considerations

On the basis of the draft guidelines of the INSPIRE Data Specification on Air Transport Networks a revised data model shall be developed to meet the demands of environmental issues (INSPIRE is primarily built for), the fields of application the draft proposes, and AIM. The data model shall make INSPIRE suitable as a framework for a European aeronautical SDI and set a counter movement to the EAD initiative.

First of all this ambition requests the revision of the overlapping spatial data themes, the life cycle concept as well as the determination of the data quality requirements. There is the need for an elaboration of a modification concerning the topology model due to the problems stated in chapter 3.4.4.1. Furthermore an adjustment of the spatial object type (feature type) structure and their relationships is essential. New spatial object types, enumerations, and code lists have to be defined so that all fields of application are sufficiently supported with data. Finally an enhancement of existing spatial object types by the introduction of new attributes is needed to achieve the objective.

4.1.1 Overlapping spatial data themes

Opposite to the suggestions of the INSPIRE publication (INSPIRE, 2008a) the air transport theme has important links and overlaps with the following other proposed spatial data themes:

- *Elevation:* The spatial data theme elevation contains DEMs and DTMs (digital terrain model) as regular grid in different resolution for land surfaces. The accuracy and the resolution of the data decide whether they are suitable for aeronautical purposes that are presented in chapter 2.2.3.6 of this work (ICAO, 2004b). The aeronautical information community is expecting benefits from using terrain data provided by INSPIRE in consideration of the eTOD project.

- *Buildings:* This spatial data theme could be used for man-made obstacles pertinent for aviation and for detailed information concerning airport structures and navigation aids. To ensure that the data are useful for AIM, they have to meet the requirements of ICAO Annex 15 (ICAO, 2004b) (presented in chapter 2.2.3.6). Additionally the data model for building would have to be expanded by information crucial for AIM (e.g. height, lighting/marking).

- *Atmospheric conditions:* Physical conditions of the atmosphere including spatial data based on measurements and the observation locations are contained in this spatial data theme. Usually each international airport practices local meteorological observations mandatory for operations (ICAO, 1995b). Additional national monitoring is done at different representative locations. The possible integration of these data into a total weather model is not part of this thesis.

- *Meteorological geographical features:* This spatial data theme contains weather conditions including measurements of precipitation, temperature, evatranspiration, wind speed, and wind direction. Usually each international airport practices local meteorological observations mandatory for operations (ICAO, 1995b). Additional national monitoring is done at different representative locations. The possible integration of these data into a total weather model is not part of this thesis.

The main problem with the overlapping spatial data themes defined by INSPIRE is that they will become operative in 2012 at the earliest. For AIM this is not acceptable and therefore it is necessary to partially implement information in the air transport network data theme due to safety reasons (e.g. aerodrome infrastructure, obstacles).

4.1.2 Temporal concept

The life cycle concept described in the draft guidelines of the INSPIRE GNM has to be adjusted to be suitable for the AIRAC and NOTAM concept of ICAO, that complies all aeronautical information. Due to the fact that the validity of aeronautical information can last several times the multiplicity factor of the validity of aeronautical information is changed (Fig. 25; Fig. 27; Fig. 28). For instance a waypoint can be part of an air route network for some AIRAC cycles then the network changes and the validity of the waypoint expires. Another change in the network may lead to the reuse of a waypoint (for another air route).

4.1.3 Data quality requirements

The data quality issues of all attributes defined for the data model have to meet the requirements of ICAO Annex 15 (ICAO, 2004b) and of the ADQ (EUROCONTROL, 2007) presented in chapter 2.2.3.4 of this thesis.

4.2 Topology concept

The most important change in the topology concept is done within the aerodrome area (Fig. 23). Due to the resulting distortion between the different transport network subthemes when using the ARP for connectivity (chapter 3.4.4.1), the aerodrome point is displaced to the main entrance of the aerodrome. Usually the road and rail network end here. Additionally this node is used for connectivity purposes only. The ARP is not dismissed because of its importance in daily aviation and becomes a new spatial object type which contains the main information concerning an aerodrome.

The starting point of a SID and the end point of an IAP are represented by a new defined spatial object type called runway threshold point. This point indicates location and height of the runway threshold, which marks the point where published SIDs usually start and the touch-down of the IAP is located.

The distance between the aerodrome point and the runway threshold point is described by a newly introduced link, the aerodrome connector. This link feature indicates the (fictitious) distance the passenger is covering within the aerodrome area (by foot, bus, or aircraft).

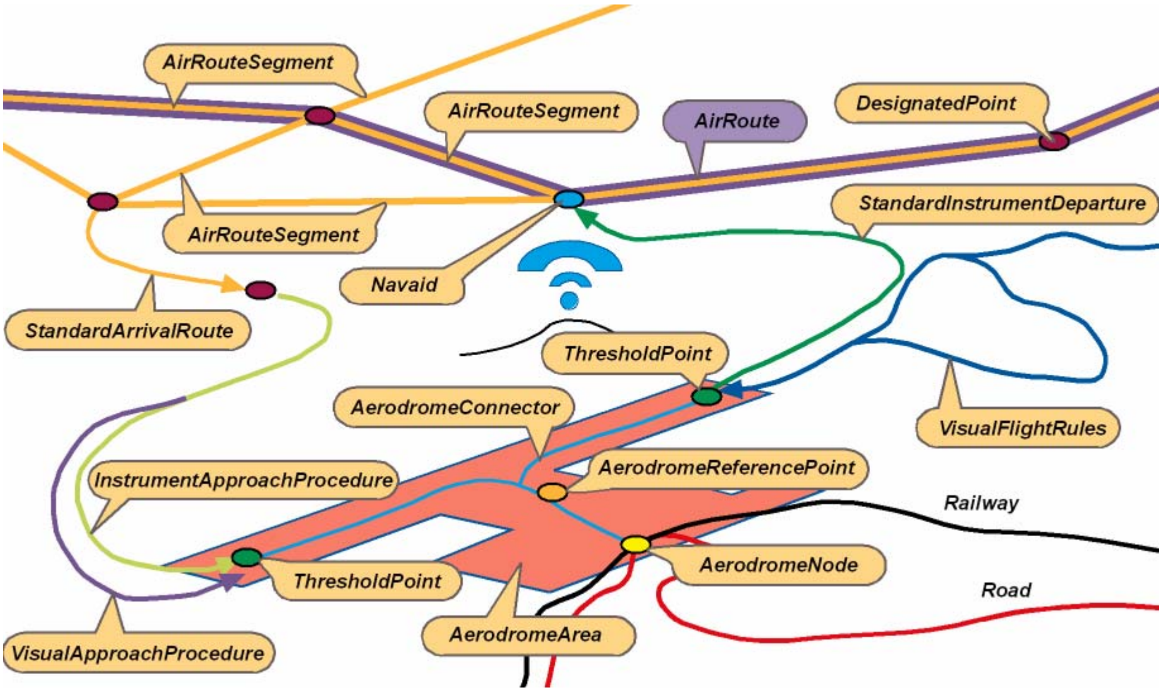

Fig. 23: Modified topology concept

Furthermore the transport links are simplified and all movements of an aircraft in the air are summarised in the spatial data type air route. A differentiation between the air route types is done by different attributes.

Finally the aerodrome area has been diversified in its main parts of usage in order to provide more detailed information concerning the apron, the clearway, the infrastructure area, the stopway, and the taxiway (Fig. 24).

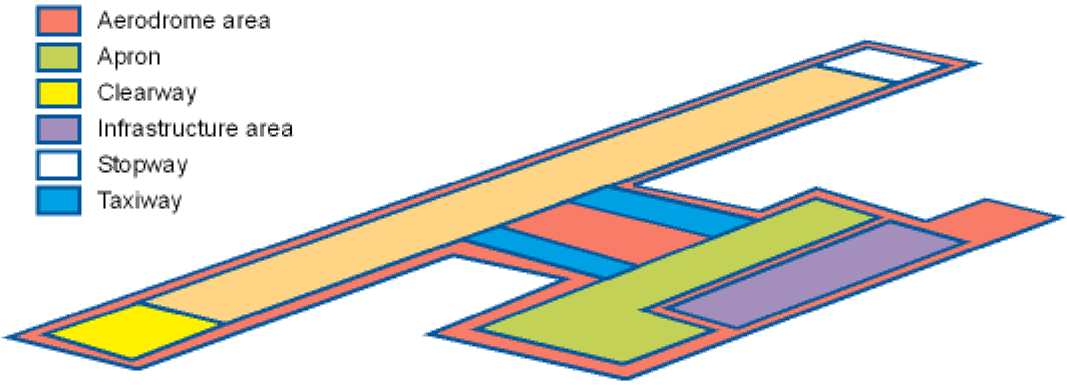

Fig. 24: Aerodrome area concept

4.3 Spatial object types

This chapter shows the improvements of the data model at a glance. A detailed description of all feature types including their attributes are provided in the appendix (part A.1) of this thesis.

4.3.1 Node features

The air node feature type has been extended to four subtypes (Fig. 25):

- The *aerodrome point* is used for connectivity purposes only. On the one hand it serves as the connection to the different the Transport Networks subthemes like road and rail. On the other hand it is used as start and end point of movements within the aerodrome area. (Fig. 26)

- The *aerodrome reference point* inherits the basic data concerning an aerodrome. The attached attributes to that feature type have been enhanced to provide aerodrome information essential for AIM including the identification (ICAO and IATA (International Air Transport Association) code), the classification (e.g. aerodrome category, traffic schedule, traffic type, working hours), and fundamental information concerning ATC (e.g. main tower frequency, emergency telephone number). (Fig. 26)

- The *air significant point* represents points that are part of the air route system from the take-off phase to the landing phase. This spatial object type is divided into three subthemes based on the usage of the point:

    - The *designated point* represents a named geographic location, used in defining an ATS route. Additionally information is supported concerning the required behaviour at this designated point in consideration of reporting, flyover, and flight altitude. (Fig. 26)

    - The *navaid point* represents the exact location where a navaid is placed to support ATS. The INSPIRE draft only differentiates between the navaid type (e.g. NDB, DME) but no special information is delivered which is needed for air navigation. Now the definitions of all important attributes concerning navaids are procured like the identification, the frequency, or the channel where ATS is provided. (Fig. 26)

  - The *runway threshold point* is newly-made and represents the runway threshold coordinates including the ground elevation where the take-off point and the touch-down of an aircraft are situated. This feature type serves as connection between the ground movement and the flight phase of an aircraft because it is the initial point of a published SID or the final point of a published IAP. (Fig. 26)

- The newly-made *obstacle point* represents all fixed or mobile objects extending to a height where they could be dangerous to aircraft during the surface movement or flight phase (Fig. 26). Obstacles can either be a natural (e.g. a prominent tree) or a man-made feature (e.g. tower, antenna, cable car). The data model demands three heights for a complete description of an obstacle (base height, construction height, and top elevation). At least two of them are essential whereas the third can be derived from the others. This feature type may not have direct impact on environmental issues but due to their existence air routes or procedures for take-off and landing are customised. Obstacles are a good example for clarifying the needs of different units of measurement (Fig. 31). Usually obstacle (or building) heights are collected in metres. But the pilot or an FMS needs the information in feet to fit their needs. Obstacles pertinent for air navigation may be part of the spatial data theme buildings which should be available in 2012 at the earliest, but far too late for AIM. The different height information concerning obstacles as well as the lighting information is safety relevant. For the time being the NSDI draft concept of Austria inherits obstacles as an independent spatial layer unlike INSPIRE.

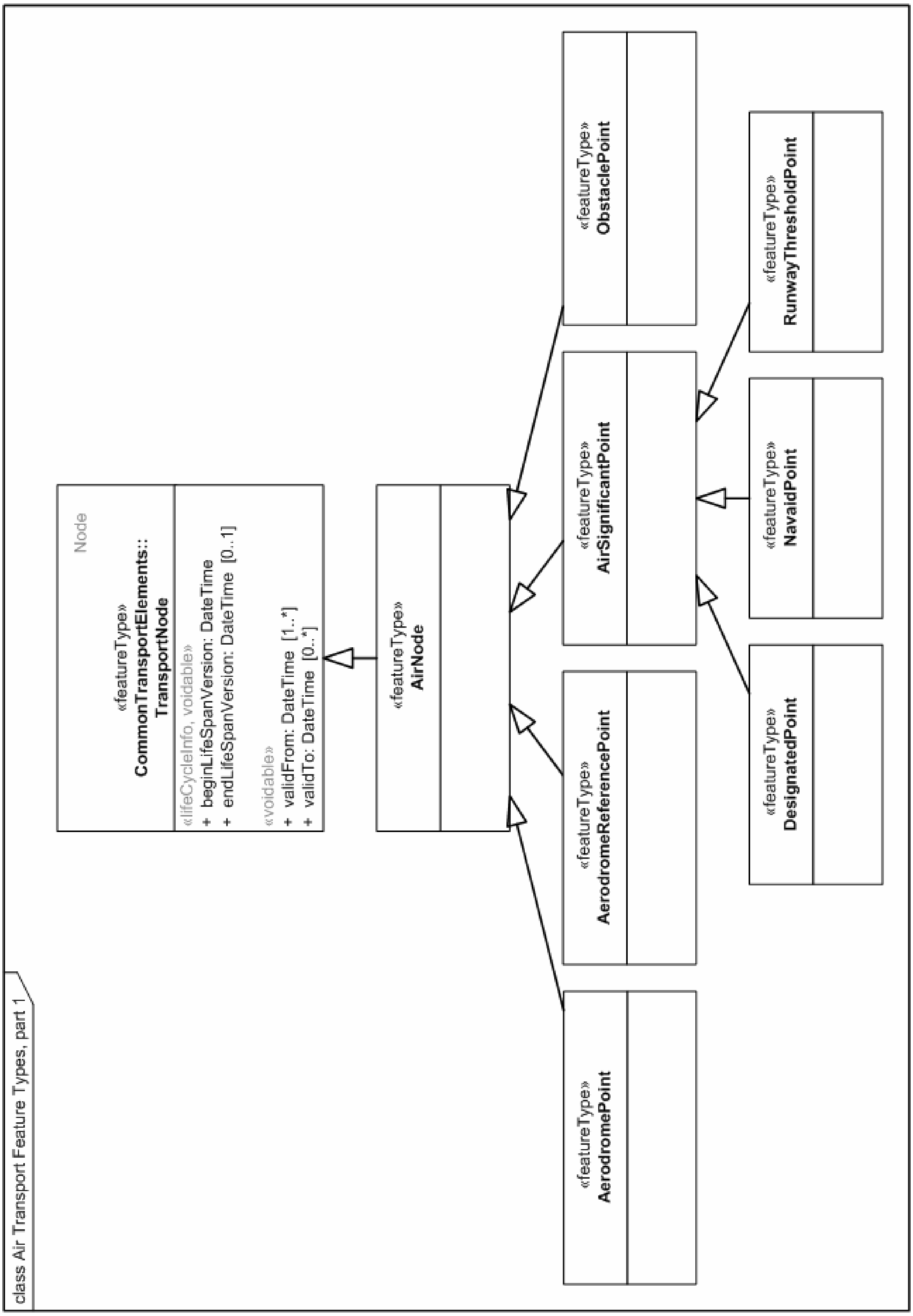

Fig. 25: class Air Transport Feature Types, part 1: node overview

Fig. 26: class Air Transport Feature Types, node details

4.3.2 Link features

The transport link feature type still has two subtypes but there is a big difference to the INSPIRE draft (Fig. 27):

- In the present data model all information concerning airways is stored in one class called *air route segment* albeit it is about the take-off, the different en-route types, or landing phases (STAR, IAP, VAP (visual approach procedure)), or even VFR. While the INSPIRE draft only asks for lowest safe altitude and upper altitude of an airway, this data model additionally supports information concerning traffic flow management along these airways. Air route segments are assigned to the different flight phases and are attached to an aerodrome. Information concerning flight direction, flight level relating to the airspace, (reverse) magnetic tracks, slope, and maximum speed is essential in different fields of aeronautical application.
- The feature type *aerodrome connector* is newly-made and is used to connect the aerodrome point with the runway threshold point. It represents the fictitious route a passenger covers from the entrance of the aerodrome to the runway threshold, including the footway within the buildings, a bus ride at the apron to the aircraft, and taxiing with the aircraft. The implementation of this connector enhances the topology concept and keeps different applications from imprecise results concerning distances or journey time.

4.3.3 Aggregated link features

The aggregated transport link feature type is identical in construction to the draft guidelines of the INSPIRE Data Specification on Air Transport Networks (Fig. 27). The only aggregated transport link of the air transport network is the feature type air route. An air route consists of an ordered collection of air route segments defining the air route (Fig. 17), is identified by the air route type (SID, different en-route types, STAR, IAP, VAP, or VFR) and the eponymous route designator.

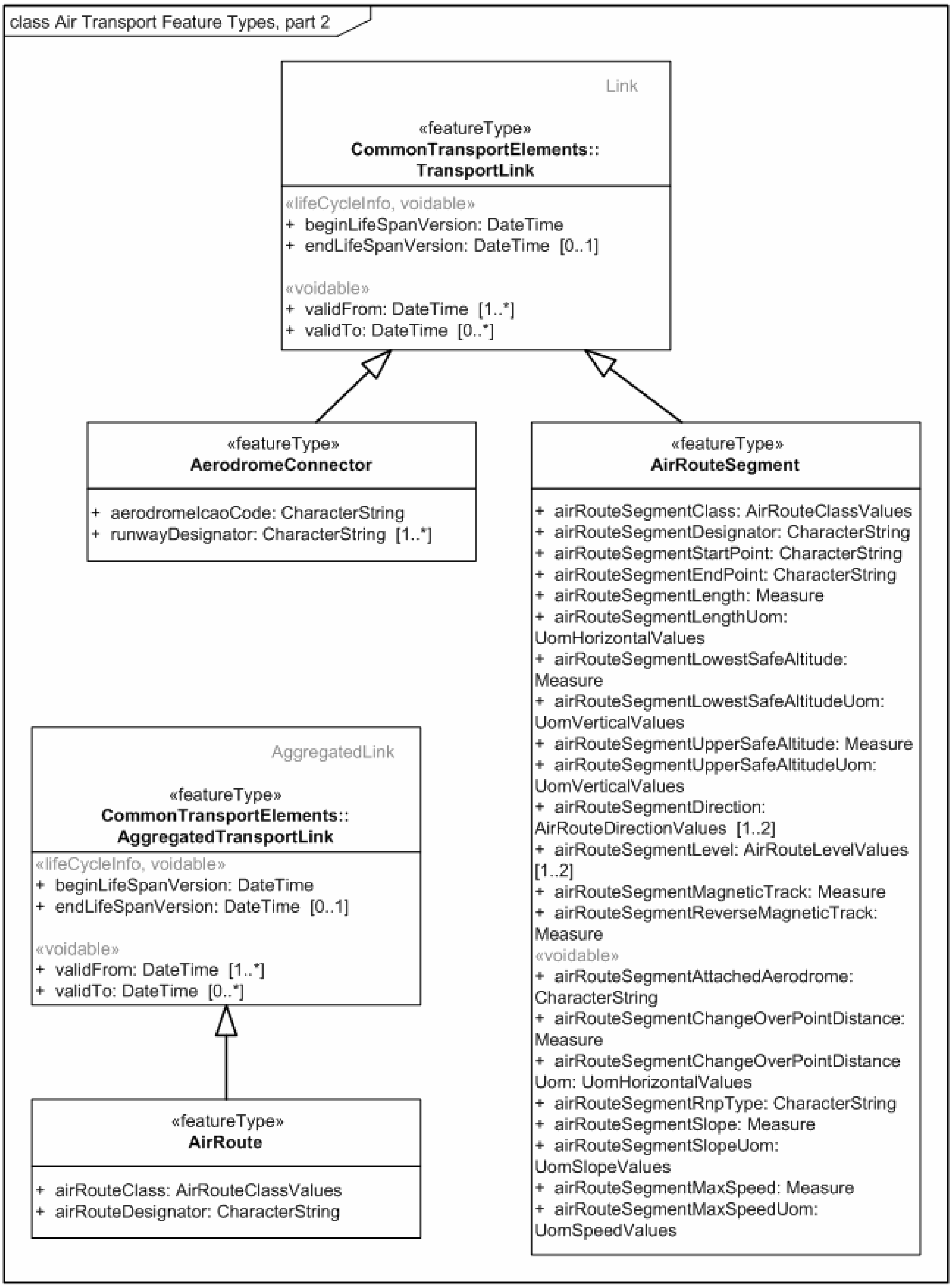

Fig. 27: class Air Transport Feature Types, part 2: link and aggregated link overview and details

4.3.4 Area features

The subthemes of the transport area feature type have been rearranged (Fig. 28). Whereas the airspace area persists in an enhanced version the runway area is integrated in the aerodrome area. Additionally the aerodrome area has been extended to various subthemes according to the aerodrome area concept shown in Fig. 24.

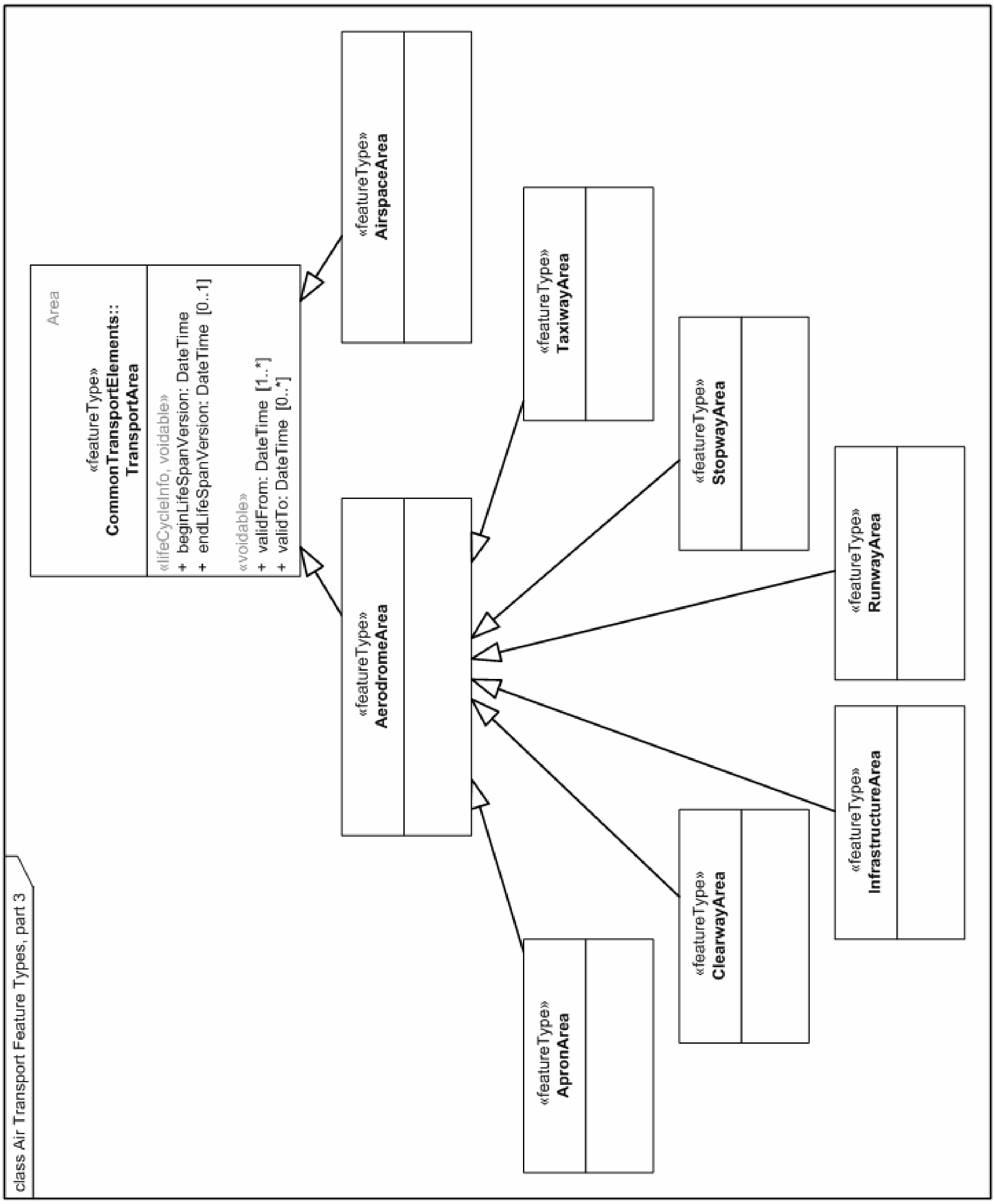

Fig. 28: class Air Transport Feature Types, part 3: area overview

- The *aerodrome area* represents the topographical limits of the facilities of an inland aerodrome extended with important detailed infrastructure information including their condition (Fig. 28). The aerodrome area resembles approximate the Area 3 of the ICAO area concept for eTOD (ICAO, 2004b) presented in chapter 2.2.3.6 of this thesis. Additionally data of this area are used for the production of AMDBs. The aerodrome area is made up of the following six subthemes which are graphically depicted in Fig. 24.

    - The *apron area* represents 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 (ICAO, 2001a). Attributes describing these functionalities like the surface or parking/docking information (e.g. maximum wingspan) are defined in this feature type. (Fig. 29)

    - The *clearway area* represents an area on the ground or water, selected or prepared as a suitable area over which an aircraft may make a portion of its initial climb to a specified height (ICAO, 2001a). Attributes describing the dimensions and the surface are defined in this spatial object type. (Fig. 29)

    - The *infrastructure area* can be summarised as all buildings and (technical) equipment of an aerodrome to ensure safety and customer care for aircraft (Fig. 29). Attributes describing the ATS frequencies, beacons, fire fighting, rescue, removal, and clearing facilities are defined in this feature type. Additionally information concerning passenger, cargo, refuelling, deicing, hangar, and repairing facilities are supported. Parts of this feature type could be "outsourced" to the spatial data theme buildings which is not defined yet but has to be made available in 2012 (EC, 2007b; INSPIRE, 2008a).

    - The *runway area* represents a defined rectangular area on a land aerodrome prepared for the landing and take-off of aircraft (ICAO, 2001a). Attributes describing physical characteristics of the runway, the declared distances, and the different lighting types available are defined in this spatial object type. (Fig. 30)

    - The *stopway area* represents an 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 (ICAO, 2001a). Attributes describing the dimensions, the surface, and the slope are defined in this feature type. (Fig. 29)
    - The *taxiway area* represents one or more defined paths on a land aerodrome established for the taxiing of aircraft or helicopters. A taxiway is intended to link different parts of the aerodrome. Attributes describing nomenclature, dimensions, surface, and slope are defined in this spatial object type. (Fig. 30)

- The *airspace area* represents the three-dimensional portion of the atmosphere controlled by a particular country on top of its territory and territorial waters (Fig. 30). Additionally to the airspace type and the lower and upper limits of the airspace that are defined in the INSPIRE draft, the airspace class, the working hours, and the information whether an airspace is controlled by a civil or military ANSP is included because they may be essential for environmental issues, ATM, and ATC (e.g. aircraft types that come across).

Fig. 29: class Air Transport Feature Types, area details 1

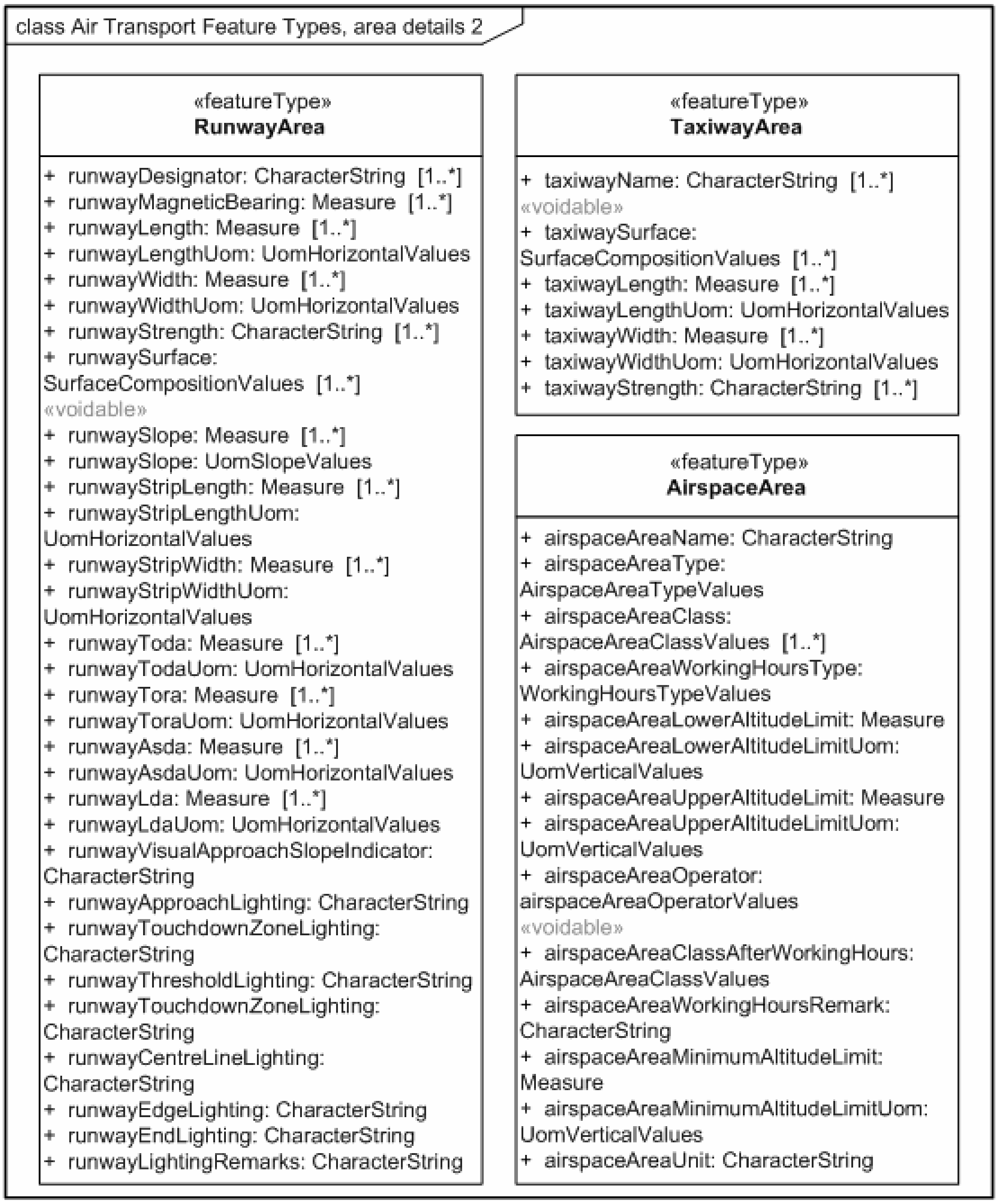

Fig. 30: class Air Transport Feature Types, area details 2

4.4 Enumerations and code lists

The number of enumerations and code lists is more than quadruplicated for this data model because of the huge amount of specified attributes. A detailed description of all enumerations and code lists is provided in the appendix (part A.2) of this work.

The needed look-up tables for the data model can be thematically compiled as follows:

- Enumerations and code lists concerning *airspace* specification are shown in Fig. 31. First of all the crucial airspace classification is supported defining the flight rules and interactions between aircraft and ATC. Moreover the code list containing the airspace types has been updated from 10 to 23 types. Finally an indexing in civil or military airspaces is done. A combination of the airspace type and the airspace operator may indicate to possible aircraft types (glider, airliner, tactical planes) that can be found within an airspace. This leads to a guesstimate to the environmental impact concerning emission and noise.

- One main block of enumerations had to be established because of the different *units of measurement* that are used in air navigation. Units of measurement concerning frequencies, horizontal and vertical distances, slope, and speed are defined (Fig. 31). The data quality issues of the data have to meet the demands defined in the ICAO Annex 15 (ICAO, 2004b) presented in chapter 2.2.3.4 of this thesis.

- An enumeration specifying the different occurring types of *working hours* of an aerodrome, aerodrome facility, airspace, or navaids is established to support the user with the information when he can anticipate with ATS at or from a structure (Fig. 31).

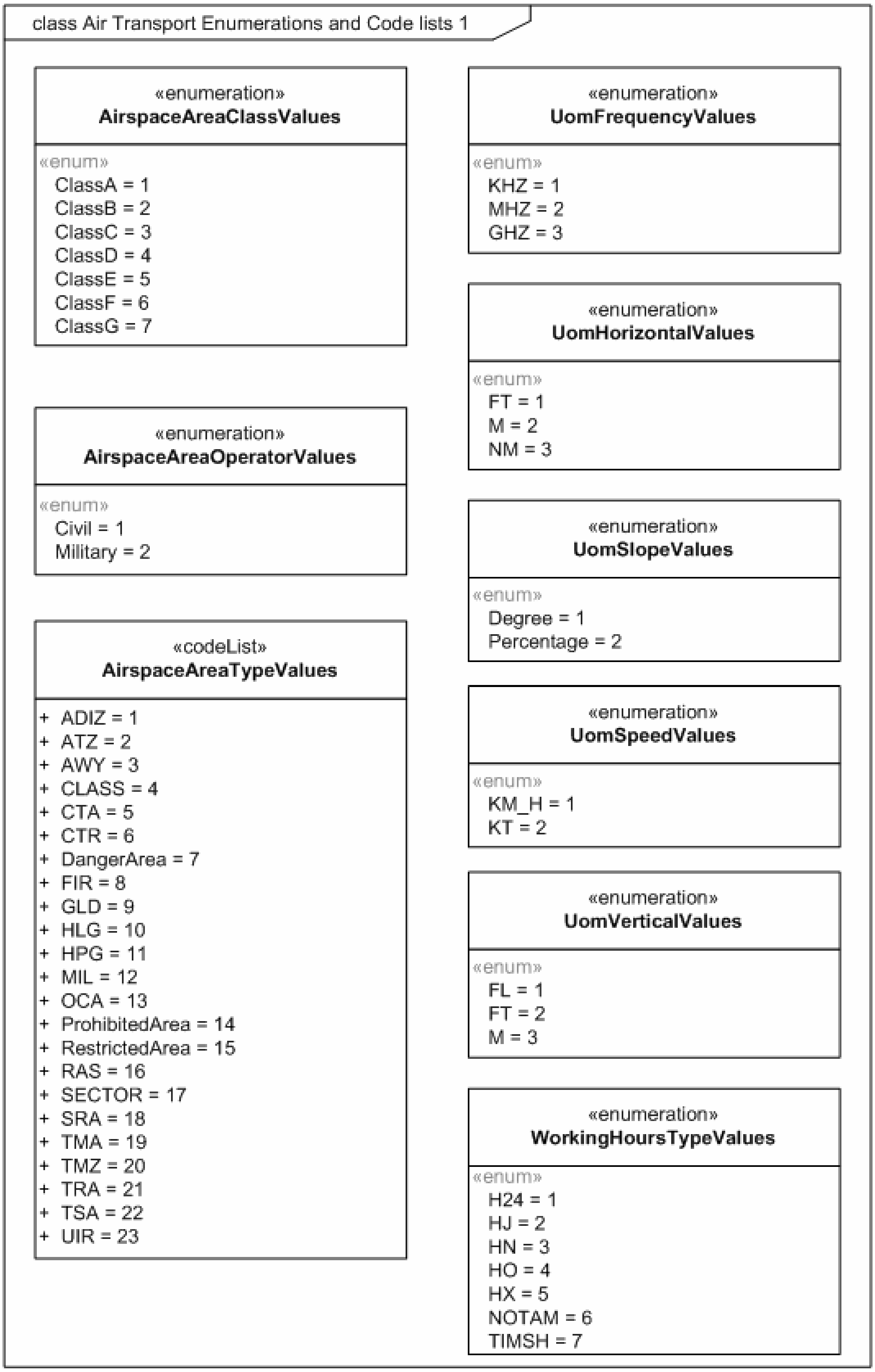

Fig. 31: class Air Transport Enumerations and Code lists 1

- The specification of the *aerodrome* leads to another group of enumerations and code lists. Differentiation of the aerodrome type and category, the supported traffic, the surface composition of the aerodrome area, and the provided ATS services can be pointed out now. (Fig. 32)

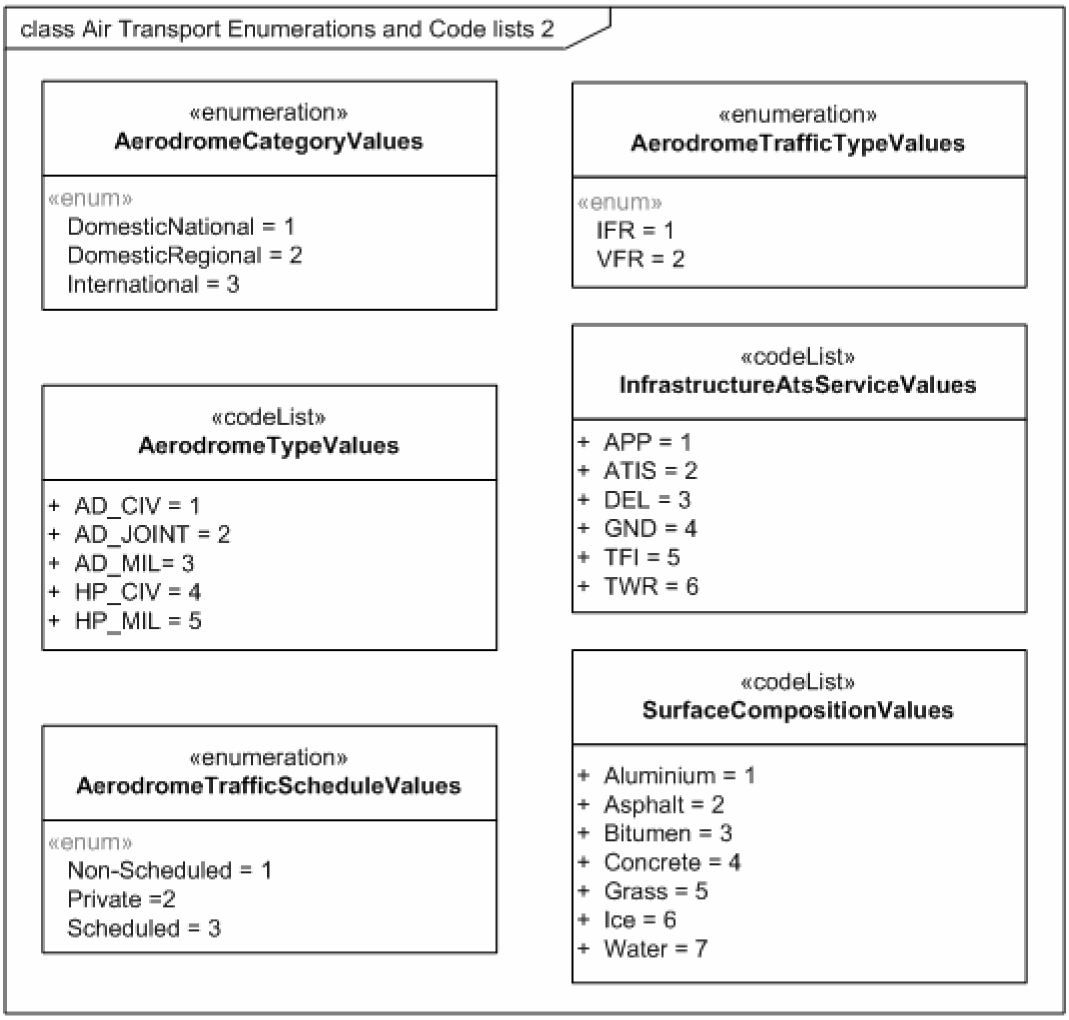

Fig. 32: class Air Transport Enumerations and Code lists 2

- Enumerations and code lists are defined concerning *air routes* and *designated points*. They are describing the performance the aircraft has to operate concerning traffic flow direction, reporting behaviour, and elevations that are to be adhered. Furthermore the air route type code list is enhanced and so there is now the possibility to differ between all recent air route type (SID, different en-route types, STAR, IAP, VAP, or VFR) and attach relevant important attributes. An improved code list of navaid classes rounds off the information concerning designated points. (Fig. 33)

- Finally a differentiation between lighted or marked *obstacle* identification is done because it is mandatory to the knowledge of the pilot (Fig. 33).

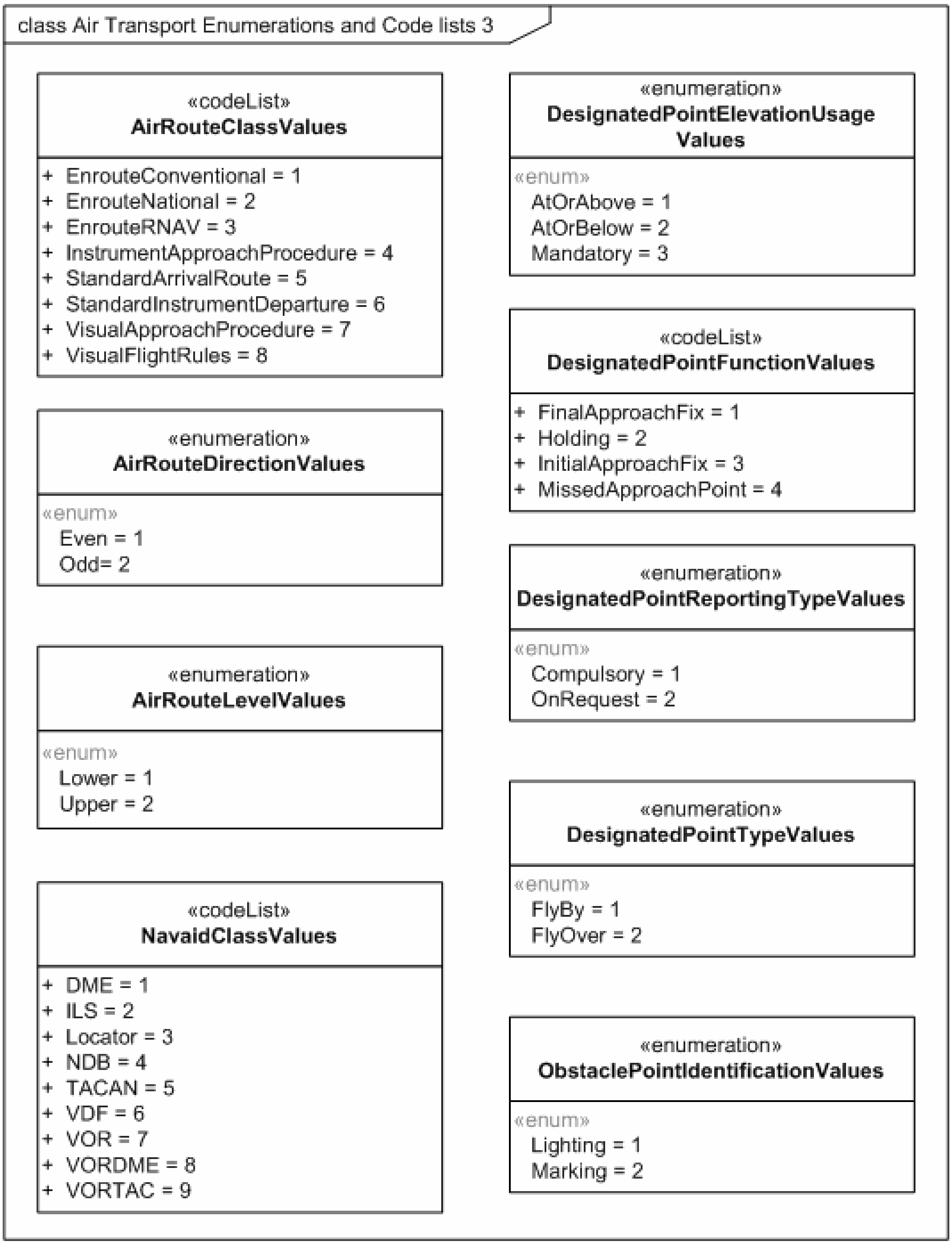

Fig. 33: class Air Transport Enumerations and Code lists 3

4.5 Conclusion and results

First of all the surroundings of the air transport data theme was examined and it emerged that the INSPIRE spatial data themes elevation, buildings, atmospheric conditions, and meteorological geographical conditions have a strong relationship to aviation purposes.

The temporal concept defined by INSPIRE had to be adjusted to meet the aviation needs in particular the AIRAC and NOTAM requirements. Moreover it was adhered that data quality issues of the data model have to be identical to these defined in the ICAO Annex 15 and ADQ to fit the demands of AIM.

The topological concept was adapted in order to minimise distortions in the connectivity to other transport subthemes (road, rail, and water). Additionally the adaptation mirrors the realities in air navigation much more lifelike.

A comparison of the scale characteristics of the UML model concerning air transport network provided by INSPIRE and the data model defined in this thesis is conducted in Tab. 5. Although there is no big difference in the amount of the feature types in the UML models, major differences can be found in the number of the defined attributes, enumerations, and code lists including their values. This indicates that the UML model in the thesis is much more explicit and more information is maintained in order to be suitable as a framework for European aeronautical data exchange. This leads to the assumption that the requirements of the fields of application, in fact the INSPIRE draft should support (chapter 3.4.4), can be fulfilled better.

Scale of the air transport network UML model	INSPIRE draft	Thesis draft
Feature types	18	23
Attributes	19	191
Enumerations and code lists	6	24
Enumeration and code list values	26	102

Tab. 5: Characteristics concerning the scale of the UML models (INSPIRE draft vs. thesis draft)

In the subsections 3.4.4.2 to 3.4.4.5 of this work it is shown that the INSPIRE draft is not able to answer concrete examples of several target fields of application due to the limitations of the provided spatial object types and attributes. The modifications and enhancements of the UML model accomplish these tasks. The integration of detailed information concerning the aerodrome infrastructure, runways, obstacles, air routes during take-off and landing phase, and airspaces solves these exemplary demands of AIM clearly.

All in all the mentioned modifications were necessary to meet the requirements of AIM in terms of establishing INSPIRE as the basis of an aeronautical ESDI. The usage of UML stood the test of big transformation and it will be a great convenience due to the fact that changes in the data model of the ESDI are pronounced in future. The integration of future AIM tasks like the AMDB, the Area 3 eTOD information, or by 2012 when the overlapping spatial data themes shall be introduced will be further pieces to reach the common goal of SESAR, an aeronautical EDSI.

5 Conclusion, discussion, and future research

5.1 Conclusion

In the first section of this work the divergent audience should be familiarised with the theoretical concepts of an SDI and AIM. The international standards AIM is based on are depicted in detail because an SDI has to meet these special requirements to be applicable for aviation purposes. Additionally future developments and imperatives concerning these topics are revised and a connection between SDI and AIM is clarified in the European initiatives of INSPIRE and SESAR. The main goal of this section is to raise the awareness of the advantages of SDI and the opportunities an SDI provides to AIM.

Although the technical progress concerning information provision and exchange via data infrastructures is heading for a different direction, at present a centralised solution like the EAD is provided for AIM at a European level. So far the aviation community did not consider the INSPIRE initiative as an adequate platform for data provision and exchange even though aeronautical information shall be provided via this ESDI.

This work seizes the idea and reviews the draft guidelines of the INSPIRE Data Specification on Air Transport Networks to identify whether they are suitable as an aeronautical data exchange platform in the sense of a European aeronautical SDI. The results show that the INSPIRE data model on air transport needs some improvement and essential information is missing to meet the demands of environmental issues and AIM. Lack of information leads to problems in using the data model for considered fields of application in AIM.

Based on the review results general modifications of the data model are provided with the objective of meeting the requirements of INSPIRE and AIM. Important links and overlaps with the proposed INSPIRE spatial data themes elevation, buildings, atmospheric conditions, and meteorological geographical conditions are found. Unfortunately these spatial data themes are introduced to INSPIRE in 2012 at the earliest. The temporal concept is adapted in order to fulfil the required AIM demands concerning AIRAC and NOTAM. The provided topological concept of connectivity to other transport subthemes like road, rail, and water is modified to suit the realities in air navigation and to minimise discovered problems.

UML is used to describe and depict the modifications and enhancements of the data model itself. Major changes are made concerning the definitions of feature types, attributes, enumerations, and code lists. The UML model in the thesis is much more explicit than the INSPIRE draft (Tab. 5). Supplementary information is maintained in order to be suitable as a framework for European aeronautical data exchange from the perspective of AIM. Moreover the defined data model is expandable which is important to integrate future AIM tasks to the data model of the aeronautical EDSI (e.g. AMDB, eTOD Area 3).

Hopefully this work raises the awareness in the aviation industry that INSPIRE and the data model defined in this work could be an important piece of a puzzle in the SESAR programme as this work is an important contribution to the design of INSPIRE from the aeronautical user perspective.

5.2 Discussion

This thesis covers the aspects of a data model for an ESDI from the point of an aeronautical user only. The data model is no more than a small piece of an SDI but for the (aeronautical) user it might be the most important one.

The main shortcoming of this thesis is the fact that the defined data model for data exchange within an aeronautically enabled INSPIRE initiative is not reviewed by an aeronautical test case but sticks to a formal basis. A final assessment of the provided data model is not possible until INSPIRE is operational.

The result of this thesis is only a small first step towards a complete and usable INSPIRE initiative from the perspective of AIM. Moreover it is essential that the SESAR programme deals with the INSPIRE subject and derives advantage from its integration because the aviation industry can benefit from the abandonment of its narrow perspective concerning aviation solely.

Anyway, until a fully established and aeronautically enabled ESDI is supporting the ANSPs and their customers a big amount of research, capacity building, and awareness raising has to be done in the aviation community at a national and European level.

5.3 Potential of further investigation

The examination of the implementation of a data model for aeronautical purposes in the context of INSPIRE offers additional fields for further investigation which are no longer possible in the context of this work.

First of all further research is needed in the applied implementation of the defined data model using an aeronautical test case.

Due to the fact that an air transport network is connected to other spatial data themes than a road, rail, or water network this connectivity has to be explored and specified. Especially the data themes of elevation and buildings are important, that are included in the INSPIRE initiative in 2012. These newly introduced spatial data themes have to be aeronautically enabled to be usable for AIM. At the same time the data model on air transport network might be adjusted concerning the obstacles and the aerodrome infrastructure.

In a second step of the INSPIRE initiative when a higher level of detail is aimed the AerodromeConnector could be replaced by the real ground movement routes on an aerodrome. The feature types of the road network class could be used for the pedestrian paths and bus lanes. In accordance with the aircraft parking positions and the taxiways the accuracy of the data model would be top.

Potential for further investigation offers the adaptation of the data model, especially the aerodrome area, concerning the specification for the more detailed needs of an AMDB because their implementation is an important task for ANSPs in the near future. Furthermore the aerodrome area is quite ident to the Area 3 of the area concept for terrain and obstacle data defined in ICAO Annex 15. The integration of these two upcoming geospatial AIM topics in the concept of a European (aeronautical) SDI is an inevitable important next step.

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Curriculum Vitae

Personal Details

Name: **MAG. KLINGER GERNOT OLIVER**
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Education

1984 – 1988	Elementary School II, Vöcklabruck, Austria
1988 – 1996	High School Vöcklabruck (Focus on Languages), Austria
10/1996 – 01/1997	Studies in Geography at Salzburg University, Austria
03/1998 – 09/2000	Studies in Geography and Regional Research at the University of Vienna, Austria
10/2000 – 06/2004	Studies in Cartography at the University of Vienna, Austria
21.06.2004	Degree (Mag. rer. nat.) in Cartography
01/2006 – 04/2009	UNIGIS MSc programme „Geographical Information Science & Systems“ (UNIGIS MSc) at the Centre for GeoInformatics (Z_GIS), Salzburg University, Austria

Professional Experience

02/1997 – 12/1997	Community Service, Red Cross Upper Austria, Office Vöcklabruck, Austria
08/2001	Internship, Provincial Government Upper Austria, Linz, Austria – Department for Spatial Planning / Cultural Information System
10/2001 – 06/2003	Student tutorials in Cartography, GIS, and Statistics at the Department of Geography and Regional Research, University of Vienna, Austria
11/2001 – 06/2002	Employee, Freytag-Berndt u. Artaria KG, Cartographic Publishing Company, Vienna, Austria – Department of Hiking and Tourist Maps, New Media
03/2002 – 02/2003	Employee, Department of Geography and Regional Research, University of Vienna, Austria – Working Group Cartography and GIS
12/2003 – 05/2004	Employee, Federal Environment Agency, Vienna, Austria – Department of Ground Water / GIS
10/2004 – 07/2006	Employee, Vermessung AVT ZT Ges.m.b.H., Surveyor, Division Vienna/Mödling, Austria – Working Group Laserscanning, Photogrammetry, GIS
08/2006 to date	Employee, Austro Control GmbH, Vienna, Austria – Department Air Traffic Management (ATM), Business Unit Aeronautical Information Management (AIM), Working Group Static Data Management (SDM), Expert Charting-Cartography-GIS

Appendix

The detailed descriptions of the spatial object types (or feature types) as well as the enumerations and code lists are ordered alphabetically.

A.1 Spatial object types

Air Transport Network.AerodromeArea

Class: «featureType» Air Transport Network.AerodromeArea	
Definition:	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/helicopters (ICAO, 2004a). An area feature which is used to represent the topographical limits of the facilities of an inland aerodrome extended with important detailed infrastructure information.
Subtype of:	TransportArea
Status:	Proposed
Stereotypes:	«featureType»
Attribute: conditionOfFacility	
Definition:	Current overall status of the aerodrome facilities concerning its current use.
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	«voidable»

Air Transport Network.AerodromeConnector

Class: «featureType» Air Transport Network.AerodromeConnector	
Definition:	A fictitious connector designed for connecting the AerodromePoint with the RunwayThresholdPoint. This connector can be imagined as a link of the distance between the entrance of the aerodrome to the runway threshold, including a footway, a bus ride to the aircraft, and taxiing with the aircraft.
Subtype of:	TransportLink
Status:	Proposed
Stereotypes:	«featureType»
Attribute: aerodromeIcaoCode	
Definition:	ICAO code of the aerodrome.

Value type:	CharacterString
Multiplicity:	1
Stereotypes:	
Attribute: runwayDesignator	
Definition:	Name of the runway (e.g. 16L).
Value type:	CharacterString
Multiplicity:	1..*
Stereotypes:	

Air Transport Network.AerodromePoint

Class: «featureType» Air Transport Network.AerodromePoint	
Definition:	The aerodrome node is an AirNode representing the aerodrome. It is used as a connection between the different transport networks subthemes (road, rail, water).
Subtype of:	AirNode
Status:	Proposed
Stereotypes:	«featureType»
Attribute: aerodromeIcaoCode	
Definition:	ICAO code of the aerodrome.
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	

Air Transport Network.AerodromeReferencePoint

Class: «featureType» Air Transport Network.AerodromeReferencePoint	
Definition:	The ARP is the designated geographical location of an aerodrome, located near the geometric centre of the aerodrome and normally remaining where originally established. The ARP of an aerodrome/heliport is used to represent it in a simplified way.
Subtype of:	AirNode
Status:	Proposed
Stereotypes:	«featureType»
Attribute: aerodromeIcaoCode	
Definition:	ICAO code of the aerodrome.
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	
Attribute: aerodromeType	
Definition:	Indication of the aerodrome type including the operator information.

Value type:	AerodromeTypeValues
Multiplicity:	1
Stereotypes:	
Attribute: aerodromeCategory	
Definition:	Aerodrome categories concerning the scope and importance of the ATS offered from and to it.
Value type:	AerodromeCategoryValues
Multiplicity:	1
Stereotypes:	
Attribute: aerodromeElevation	
Definition:	The vertical distance to the highest point on the landing area of the aerodrome measured from MSL.
Value type:	Measure
Multiplicity:	1
Stereotypes:	
Attribute: aerodromeElevationUom	
Definition:	Unit of measurement of the vertical distance to the highest point on the landing area of the aerodrome measured from MSL.
Value type:	UomVerticalValues
Multiplicity:	1
Stereotypes:	
Attribute: aerodromeFrequency	
Definition:	Primary frequency (or frequencies) for ATS used by an aerodrome.
Value type:	Measure
Multiplicity:	1..*
Stereotypes:	
Attribute: aerodromeFrequencyUom	
Definition:	Unit of measurement of the primary frequency for ATS used by an aerodrome.
Value type:	UomFrequencyValues
Multiplicity:	1
Stereotypes:	
Attribute: aerodromeEmergencyTelephone	
Definition:	Emergency telephone number of an aerodrome used in case of radio communication failure.
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	
Attribute: aerodromeTrafficType	
Definition:	Indication whether an aerodrome is equipped for IFR and/or VFR.
Value type:	AerodromeTrafficTypeValues

Multiplicity:	1..2
Stereotypes:	
Attribute: aerodromeTrafficSchedule	
Definition:	Aerodrome categories concerning the kind of traffic offered from and to an aerodrome.
Value type:	AerodromeTrafficScheduleValues
Multiplicity:	1..3
Stereotypes:	
Attribute: aerodromeWorkingHoursType	
A code	A code indicating the working hours of the aerodrome.
Value type:	WorkingHoursTypeValues
Multiplicity:	1
Stereotypes:	
Attribute: aerodromeArpSiteAtAerodrome	
Definition:	A textual description of the site of the ARP at the aerodrome.
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	
Attribute: aerodromeArpElevation	
Definition:	The vertical distance to the ARP of the aerodrome measured from MSL.
Value type:	AerodromeCategoryValues
Multiplicity:	1
Stereotypes:	
Attribute: aerodromeArpElevationUom	
Definition:	Unit of measurement of the vertical distance to the ARP of the aerodrome measured from MSL.
Value type:	UomVerticalValues
Multiplicity:	1
Stereotypes:	
Attribute: aerodromeIataCode	
Definition:	IATA code of the aerodrome. Only for international airports available.
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: aerodromeWorkingHoursRemark	
Definition:	A textual remark concerning the working hours of the aerodrome.
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	«voidable»

Attribute: aerodromeReferenceTemperature	
Definition:	Aerodrome reference temperature in degree Celsius.
Value type:	Measure
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: aerodromeServedCity	
Definition:	Name of the city an aerodrome serves.
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: aerodromeMagVarValue	
Definition:	Indication of the magnetic variation of an aerodrome measured at the ARP.
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: aerodromeMagVarDate	
Definition:	Indication of the exact date of the indicated magnetic variation of an aerodrome.
Value type:	DateTime
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: aerodromeMagVarAnnualChange	
Definition:	Indication of the annual change of the indicated magnetic variation of an aerodrome.
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	«voidable»

Air Transport Network.AirNode

Class: «featureType» Air Transport Network.AirNode	
Definition:	A node which occurs in an air transport network. There are different types of air nodes: aerodrome nodes, ARPs, air significant points, and obstacle points.
Subtype of:	TransportNode
Status:	Proposed
Stereotypes:	«featureType»

Air Transport Network.AirRoute

Class: «featureType» Air Transport Network.AirRoute	
Definition:	A specified route designed for channelling the flow of traffic for the provision of

	ATS during take-off, en-route, or landing phase. An air route is an ordered collection of air route segments defining an air route, which usually is characterized by one or more thematic identifiers and/or properties.
Subtype of:	AggregatedTransportLink
Status:	Proposed
Stereotypes:	«featureType»
Attribute: AirRouteClass	
Definition:	An attribute describing the type of an air route.
Value type:	AirRouteClassValues
Multiplicity:	1
Stereotypes:	
Attribute: AirRouteDesignator	
Definition:	A code or designator that identifies an air route.
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	

Air Transport Network.AirRouteSegment

Class: «featureType» Air Transport Network.AirRouteSegment	
Definition:	A portion of a route defined by two consecutive significant points.
Subtype of:	TransportLink
Status:	Proposed
Stereotypes:	«featureType»
Attribute: airRouteSegmentClass	
Definition:	An attribute describing the type of an air route segment.
Value type:	AirRouteClassValues
Multiplicity:	1
Stereotypes:	
Attribute: airRouteSegmentDesignator	
Definition:	A code or designator that identifies an air route segment.
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	
Attribute: airRouteSegmentStartPoint	
Definition:	Ident of the designated point the air route is starting from.
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	

Attribute: airRouteSegmentEndPoint	
Definition:	Ident of the designated point the air route is ending at.
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	
Attribute: airRouteSegmentLength	
Definition:	Distance between the start and the end point of an air route segment.
Value type:	Measure
Multiplicity:	1
Stereotypes:	
Attribute: airRouteSegmentLengthUom	
Definition:	Unit of measurement of the distance between the start and the end point of an air route segment.
Value type:	UomHorizontalValues
Multiplicity:	1
Stereotypes:	
Attribute: airRouteSegmentLowestSafeAltitude	
Definition:	Altitude that defines the lower limit of an air route segment in order to provide safety for navigation.
Value type:	Measure
Multiplicity:	1
Stereotypes:	
Attribute: airRouteSegmentLowestSafeAltitudeUom	
Definition:	Unit of measurement of the lower altitude for safe flights.
Value type:	UomVerticalValues
Multiplicity:	1
Stereotypes:	
Attribute: airRouteSegmentUpperSafeAltitude	
Definition:	Altitude that defines the upper limit of an air route segment in order to provide safety for navigation.
Value type:	Measure
Multiplicity:	1
Stereotypes:	
Attribute: airRouteSegmentUpperSafeAltitudeUom	
Definition:	Unit of measurement of the upper altitude for safe flights.
Value type:	UomVerticalValues
Multiplicity:	1
Stereotypes:	
Attribute: airRouteSegmentDirection	

Definition:	Determines the direction aircraft have to fly according to the semi-circular cruising levels. This split is indispensable for bi-directional air route segments.
Value type:	AirRouteDirectionValues
Multiplicity:	1..2
Stereotypes:	
Attribute: airRouteSegmentLevel	
Definition:	Determines whether an air route is situated in the lower or upper airspace of a State.
Value type:	AirRouteLevelValues
Multiplicity:	1..2
Stereotypes:	
Attribute: airRouteSegmentMagneticTrack	
Definition:	Magnetic track between the start and the end point of an air route segment.
Value type:	Measure
Multiplicity:	1
Stereotypes:	
Attribute: airRouteSegmentReverseMagneticTrack	
Definition:	Reverse magnetic track between the end and the start point of an air route segment.
Value type:	Measure
Multiplicity:	1
Stereotypes:	
Attribute: airRouteSegmentAttachedAerodrome	
Definition:	An attribute describing the aerodrome which a point of a SID, STAR, IAC, VAP, or VFR is attached to.
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: airRouteSegmentChangeOverPointDistance	
Definition:	Distance to the change over point along an air route segment.
Value type:	Measure
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: airRouteSegmentChangeOverPointDistanceUom	
Definition:	Unit of measurement of the distance to the change over point along a segment.
Value type:	UomHorizontalValues
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: airRouteSegmentRnpType	
Definition:	Required navigation performance type an aircraft has to perform to fly along the

	air route segment.
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: airRouteSegmentSlope	
Definition:	Slope between the start and the end point of an air route segment if they are located at different heights.
Value type:	Measure
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: airRouteSegmentSlopeUom	
Definition:	Unit of measurement of the slope between the start and the end point of an air route segment if they are located at different heights.
Value type:	UomSlopeValues
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: airRouteSegmentMaxSpeed	
Definition:	Allowed maximum speed of an aircraft between the start and the end point of a segment.
Value type:	Measure
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: airRouteSegmentMaxSpeedUom	
Definition:	Unit of measurement of the allowed maximum speed of an aircraft along an air route segment.
Value type:	UomSpeedValues
Multiplicity:	1
Stereotypes:	«voidable»

Air Transport Network.AirSignificantPoint

Class: «featureType» Air Transport Network.AirSignificantPoint	
Definition:	A specified geographical location used to define an ATS route, the flight path of an aircraft, or for other navigation/ATS purposes. There are different types of significant points: navigation aids, designated points, and runway threshold points.
Subtype of:	AirNode
Status:	Proposed
Stereotypes:	«featureType»

Air Transport Network.AirspaceArea

Class: «featureType» Air Transport Network.AirspaceArea	
Definition:	Airspace means the three-dimensional portion of the atmosphere controlled by a particular country or ANSP on top of its territory and territorial waters.
Subtype of:	TransportArea
Status:	Proposed
Stereotypes:	«featureType»
Attribute: airspaceAreaName	
Definition:	Name of the airspace.
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	
Attribute: airspaceAreaType	
Definition:	According to the purpose and usage of airspace specific characteristics are established.
Value type:	AirspaceAreaTypeValues
Multiplicity:	1
Stereotypes:	
Attribute: airspaceAreaClass	
Definition:	Airspace class of a specific airspace. An airspace can be divided horizontally by different classes.
Value type:	AirspaceAreaClassValues
Multiplicity:	1..*
Stereotypes:	
Attribute: airspaceAreaWorkingHoursType	
Definition:	Working hours of a specific airspace.
Value type:	WorkingHoursTypeValues
Multiplicity:	1
Stereotypes:	
Attribute: airspaceAreaLowerAltitudeLimit	
Definition:	Lower altitude limit of an airspace.
Value type:	Measure
Multiplicity:	1
Stereotypes:	
Attribute: airspaceAreaLowerAltitudeLimitUom	
Definition:	Unit of measurement of the lower altitude limit of an airspace.
Value type:	UomVerticalValues
Multiplicity:	1
Stereotypes:	

Attribute: airspaceAreaUpperAltitudeLimit	
Definition:	Upper altitude limit of an airspace.
Value type:	Measure
Multiplicity:	1
Stereotypes:	
Attribute: airspaceAreaUpperAltitudeLimitUom	
Definition:	Unit of measurement of the upper altitude limit of an airspace.
Value type:	UomVerticalValues
Multiplicity:	1
Stereotypes:	
Attribute: airspaceAreaOperator	
Definition:	Information whether an airspace is operated by a civil or military ANSP.
Value type:	airspaceAreaOperatorValues
Multiplicity:	1
Stereotypes:	
Attribute: airspaceAreaClassAfterWorkingHours	
Definition:	Airspace class of a specific airspace after working hours of ATC.
Value type:	AirspaceAreaClassValues
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: airspaceAreaClassWorkingHoursRemark	
Definition:	A textual remark concerning the working hours of the airspace.
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: airspaceAreaMinimumAltitudeLimit	
Definition:	Minimum obstacle clearance altitude limit of an airspace.
Value type:	Measure
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: airspaceAreaMinimumAltitudeLimitUom	
Definition:	Unit of measurement of the minimum obstacle clearance altitude limit of an airspace.
Value type:	UomVerticalValues
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: airspaceAreaUnit	
Definition:	Information and name concerning the ATS unit controlling the airspace.
Value type:	CharacterString

Multiplicity:	1
Stereotypes:	«voidable»

Air Transport Network.ApronArea

Class: «featureType» Air Transport Network.AepronArea	
Definition:	The apron is 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 (ICAO, 1995b; 2004a).
Subtype of:	AerodromeArea
Status:	Proposed
Stereotypes:	«featureType»
Attribute: apronName	
Definition:	Name of the apron.
Value type:	CharacterString
Multiplicity:	1..*
Stereotypes:	
Attribute: apronSurface	
Definition:	Surface composition of the apron.
Value type:	SurfaceCompositionValues
Multiplicity:	1..*
Stereotypes:	
Attribute: apronStrength	
Definition:	Maximum weight of an aircraft allowed to move and park at the apron.
Value type:	CharacterString
Multiplicity:	1..*
Stereotypes:	
Attribute: apronParkingPositionName	
Definition:	Name of a parking position at the apron.
Value type:	CharacterString
Multiplicity:	1..*
Stereotypes:	
Attribute: apronParkingPositionWingspan	
Definition:	Maximum wingspan of an aircraft allowed to park at a specific position at the apron.
Value type:	Measure
Multiplicity:	1..*
Stereotypes:	
Attribute: apronParkingPositionWingspanUom	
Definition:	Unit of measurement of the wingspan of an aircraft allowed to park at a specific

	position at the apron.
Value type:	UomHorizontalValues
Multiplicity:	1
Stereotypes:	
Attribute: apronParkingPositionLength	
Definition:	Maximum length of an aircraft allowed to park at a specific parking position at the apron.
Value type:	Measure
Multiplicity:	1..*
Stereotypes:	
Attribute: apronParkingPositionLengthUom	
Definition:	Unit of measurement of the length of an aircraft allowed to park at a specific parking position at the apron.
Value type:	UomHorizontalValues
Multiplicity:	1
Stereotypes:	
Attribute: apronDockingPossibility	
Definition:	Information concerning the docking availability and its characteristics at a docking position.
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	

Air Transport Network.ClearwayArea

Class: «featureType» Air Transport Network.ClearwayArea	
Definition:	The clearway is a defined rectangular area on the ground or water, selected or prepared as a suitable area over which an aeroplane may make a portion of its initial climb to a specified height (ICAO, 1995b; 2004a).
Subtype of:	AerodromeArea
Status:	Proposed
Stereotypes:	«featureType»
Attribute: clearwaySurface	
Definition:	Surface composition of the clearway.
Value type:	SurfaceCompositionValues
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: clearwayLength	
Definition:	Length of the clearway.
Value type:	Measure

Multiplicity:	1
Stereotypes:	«voidable»
Attribute: clearwayLengthUom	
Definition:	Unit of measurement of the length of the clearway.
Value type:	UomHorizontalValues
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: clearwayWidth	
Definition:	Width of the clearway.
Value type:	Measure
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: clearwayWidthUom	
Definition:	Unit of measurement of the width of the clearway.
Value type:	UomHorizontalValues
Multiplicity:	1
Stereotypes:	«voidable»

Air Transport Network.DesignatedPoint

Class: «featureType» Air Transport Network.DesignatedPoint	
Definition:	A named geographical location not marked by the site of a radio navigation aid, used in defining an ATS route, the flight path of an aircraft or for other navigation or ATS purposes.
Subtype of:	AirSignificantPoint
Status:	Proposed
Stereotypes:	«featureType»
Attribute: designatedPointClass	
Definition:	An attribute describing the class or type of an air route a designated point is part of.
Value type:	AirRouteClassValues
Multiplicity:	1..*
Stereotypes:	
Attribute: designatedPointName	
Definition:	ICAO-five letter code or name of a designated point.
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	
Attribute: designatedPointReportingType	
Definition:	Indicates whether reporting of an aircraft at a designated point is compulsory or on

	request.
Value type:	DesignatedPointReportingTypeValues
Multiplicity:	1
Stereotypes:	
Attribute: designatedPointType	
Definition:	Aviation procedures make use of both fly−over and fly−by waypoints.
Value type:	DesignatedPointTypeValues
Multiplicity:	1
Stereotypes:	
Attribute: designatedPointAttachedAerodrome	
Definition:	An attribute describing the aerodrome which a point of a SID, STAR, IAC, VAP, or VFR is attached to.
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: designatedPointFunction	
Definition:	Special function of a designated point (e.g. initial approach fix).
Value type:	DesignatedPointFunctionValues
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: designatedPointElevation	
Definition:	Indicates the altitude or flight level an aircraft has to retain at a designated point due to ATC or obstacle clearance.
Value type:	Measure
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: designatedPointElevationUom	
Definition:	Unit of measurement of the altitude or flight level an aircraft has to retain at a designated point due to ATC or obstacle clearance.
Value type:	UomVerticalValues
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: designatedPointElevationUsage	
Definition:	Indicates the position to the altitude or flight level an aircraft has to retain at a designated point.
Value type:	DesignatedPointElevationUsageValues
Multiplicity:	1
Stereotypes:	«voidable»

Air Transport Network.InfrastructureArea

Class: «featureType» Air Transport Network.InfrastructureArea	
Definition:	The infrastructure area consists of all buildings and (technical) equipment of an aerodrome to ensure safety and customer care for aircraft.
Subtype of:	AerodromeArea
Status:	Proposed
Stereotypes:	«featureType»
Attribute: infrastructureAtsService	
Definition:	A code specifying the type of service represented by ATS. One service can be done via different frequencies especially on major aerodromes.
Value type:	infrastructureAtsServiceValues
Multiplicity:	1..6
Stereotypes:	
Attribute: infrastructureAtsCallSign	
Definition:	The call sign that is used for an ATS unit on radio telecommunication.
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	
Attribute: infrastructureAtsFrequency	
Definition:	The frequency or frequencies used by an ATS.
Value type:	Measure
Multiplicity:	1..*
Stereotypes:	
Attribute: infrastructureAtsFrequencyUom	
Definition:	Indicates the unit of measurement used for the ATS frequency.
Value type:	UomFrequencyValues
Multiplicity:	1
Stereotypes:	
Attribute: infrastructureAtsWorkingHoursType	
Definition:	A code indicating the working hours of the aerodrome.
Value type:	WorkingHoursTypeValues
Multiplicity:	1
Stereotypes:	
Attribute: infrastructureAtsWorkingHoursRemark	
Definition:	A textual remark concerning the working hours of the aerodrome.
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: infrastructureAbn	

Definition:	Information concerning the existence of an aeronautical beacon at the aerodrome and its characteristics like location and hours of operation.
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: infrastructureAnemometer	
Definition:	Information concerning the existence of an anemometer at the aerodrome and its characteristics like location and lights.
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: infrastructureIbn	
Definition:	Information concerning the existence of an identification beacon at the aerodrome and its characteristics like location and hours of operation.
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: infrastructureLdi	
Definition:	Information concerning the existence of a landing direction indicator at the aerodrome and its characteristics like location.
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: infrastructureSecondaryPowerSupply	
Definition:	Information concerning the existence of a secondary power supply at the aerodrome and its characteristics like switch-over time.
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: infrastructureFireFightingCategory	
Definition:	Information concerning the fire fighting category at the aerodrome according to ICAO.
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: infrastructureRescueEquipment	
Definition:	Information concerning the rescue equipment at the aerodrome.
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	«voidable»

Attribute: infrastructureRemovalCapability	
Definition:	Information concerning the capability for removal of disabled aircraft at the aerodrome.
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: infrastructureClearingEquipment	
Definition:	Information concerning the seasonal availability of types of clearing equipment at the aerodrome.
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: infrastructureClearingPriorities	
Definition:	Information concerning the clearing priorities of infrastructures at the aerodrome.
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: infrastructurePassengerFacilities	
Definition:	Information concerning the passenger facilities at the aerodrome (e.g. hotels, restaurants, transportation, medical facilities, bank or post office, tourist office, etc.).
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: infrastructureCargoFacilities	
Definition:	Information concerning the cargo-handling facilities at the aerodrome and their characteristics.
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: infrastructureRefuellingFacilities	
Definition:	Information concerning the refuelling facilities at the aerodrome (e.g. working hours and telephone number).
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: infrastructureOilTypes	
Definition:	Information concerning oil types provided at the aerodrome.
Value type:	CharacterString
Multiplicity:	1

Stereotypes:	«voidable»
Attribute: infrastructureDeicingFacilities	
Definition:	Information concerning the availability of aircraft deicing units at the aerodrome.
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: infrastructureHangarSpace	
Definition:	Information concerning the hangar space for visiting aircraft.
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: infrastructureRepairFacilities	
Definition:	Information concerning the repair facilities for visiting aircraft at the aerodrome and their characteristics.
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	«voidable»

Air Transport Network.NavaidPoint

Class: «featureType» Air Transport Network.NavaidPoint	
Definition:	Location where a radio navigation aid is placed to support ATS. It may define a vertex of one or more air routes.
Subtype of:	AirSignificantPoint
Status:	Proposed
Stereotypes:	«featureType»
Attribute: navaidPointClass	
A code	An attribute indicating the navaid type.
Value type:	NavaidClassValues
Multiplicity:	1
Stereotypes:	
Attribute: navaidPointName	
A code	Name of the navaid.
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	
Attribute: navaidPointIdent	
A code	Abbreviated designation of a navaid additionally used for morse code delivery (e.g. VOR).
Value type:	CharacterString

Multiplicity:	1
Stereotypes:	
Attribute: navaidPointWorkingHoursType	
A code	A code indicating the working hours of the navaid.
Value type:	WorkingHoursTypeValues
Multiplicity:	1
Stereotypes:	
Attribute: navaidPointFrequency	
A code	Frequency a navaid uses (e.g. NDB, VOR).
Value type:	Measure
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: navaidPointFrequencyUom	
A code	Unit of measurement of the navaid frequency.
Value type:	UomFrequencyValues
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: navaidPointChannel	
A code	Channel a navaid uses (e.g. DME).
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: navaidPointWorkingHoursRemark	
Definition:	A textual remark concerning the working hours of the navaid.
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: navaidPointMagVarValue	
Definition:	Indication of the magnetic variation of a navaid. This is important for VORs.
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: navaidPointMagVarDate	
Definition:	Indication of the exact date of the indicated magnetic variation of a navaid.
Value type:	DateTime
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: navaidPointMagVarAnnualChange	
Definition:	Indication of the annual change of the indicated magnetic variation of a navaid.

Value type:	CharacterString
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: navaidPointAntennaElevation	
Definition:	Indication of the height of a navaid antenna. This information is important for DME only.
Value type:	Measure
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: navaidPointAntennaElevationUom	
Definition:	Unit of measurement of the height of a navaid antenna.
Value type:	UomVerticalValues
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: navaidPointCollocatedNavaid	
Definition:	Ident of a collocated navaid.
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	«voidable»

Air Transport Network.ObstaclePoint

Class: «featureType» Air Transport Network.ObstaclePoint	
Definition:	All fixed (whether temporary or permanent) and mobile objects, 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. (ICAO, 2001b)
Subtype of:	AirNode
Status:	Proposed
Stereotypes:	«featureType»
Attribute: obstaclePointName	
Definition:	Textual description including name and location of an obstacle used for identification.
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	
Attribute: obstaclePointType	
Definition:	Textual description of the obstacle type (e.g. antenna, wind park, tree).
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	

Attribute: obstaclePointBaseheight	
Definition:	Measured base height of an obstacle.
Value type:	Measure
Multiplicity:	1
Stereotypes:	
Attribute: obstaclePointBaseheightUom	
Definition:	Unit of measurement of the measured base height of an obstacle.
Value type:	UomVerticalValues
Multiplicity:	1
Stereotypes:	
Attribute: obstaclePointStructureHeight	
Definition:	Measured construction height of the obstacle.
Value type:	Measure
Multiplicity:	1
Stereotypes:	
Attribute: obstaclePointStructureHeightUom	
Definition:	Unit of measurement of the measured construction height of an obstacle.
Value type:	UomVerticalValues
Multiplicity:	1
Stereotypes:	
Attribute: obstaclePointTopElevation	
Definition:	Measured top elevation of an obstacle.
Value type:	Measure
Multiplicity:	1
Stereotypes:	
Attribute: obstaclePointTopElevationUom	
Definition:	Unit of measurement of the measured top elevation of an obstacle.
Value type:	UomVerticalValues
Multiplicity:	1
Stereotypes:	
Attribute: obstaclePointIdentification	
Definition:	The identification of an obstacle by lighting or day marking supports the pilot during the flight.
Value type:	ObstaclePointIdentificationValues
Multiplicity:	1..2
Stereotypes:	
Attribute: obstaclePointConstructor	
Definition:	Name of the constructor or construction company of an obstacle.
Value type:	CharacterString

Multiplicity:	1
Stereotypes:	«voidable»
Attribute: obstaclePointAuthorisation	
Definition:	Name of the government agency that authorised the installation of the obstacle.
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: obstaclePointNotificationNumber	
Definition:	Notification number of the official notification that authorised the installation of the obstacle.
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: obstaclePointLegalBasis	
Definition:	Reference to the article which classifies obstacle types. This could be a reference to national, European, or international law (ICAO).
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: obstaclePointCableHeight	
Definition:	Measured cable height of an obstacle.
Value type:	Measure
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: obstaclePointCableHeightUom	
Definition:	Unit of measurement of the measured cable height of an obstacle.
Value type:	UomVerticalValues
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: obstaclePointCableIdentification	
Definition:	The identification of an obstacle cable by lighting or day marking supports the pilot during the flight.
Value type:	ObstaclePointIdentificationValues
Multiplicity:	1..2
Stereotypes:	«voidable»

Air Transport Network.RunwayArea

Class: «featureType» Air Transport Network.RunwayArea	
Definition:	The runway is a defined rectangular area on a land aerodrome prepared for the

	landing and take-off of aircraft (ICAO, 1995b; 2004a).
Subtype of:	AerodromeArea
Status:	Proposed
Stereotypes:	«featureType»
Attribute: runwayDesignator	
Definition:	Name of the runway (e.g. 16L).
Value type:	CharacterString
Multiplicity:	1..*
Stereotypes:	
Attribute: runwayMagneticBearing	
Definition:	Exact alignment of the runway (e.g. 163)
Value type:	Measure
Multiplicity:	1..*
Stereotypes:	
Attribute: runwayLength	
Definition:	Length of the runway.
Value type:	Measure
Multiplicity:	1..*
Stereotypes:	
Attribute: runwayLengthUom	
Definition:	Unit of measurement of the length of the runway.
Value type:	UomHorizontalValues
Multiplicity:	1
Stereotypes:	
Attribute: runwayWidth	
Definition:	Width of the runway.
Value type:	Measure
Multiplicity:	1..*
Stereotypes:	
Attribute: runwayWidthUom	
Definition:	Unit of measurement of the width of the runway.
Value type:	UomHorizontalValues
Multiplicity:	1
Stereotypes:	
Attribute: runwayStrength	
Definition:	Maximum weight of an aircraft start and land on a runway.
Value type:	CharacterString
Multiplicity:	1..*
Stereotypes:	

Attribute: runwaySurface	
Definition:	Surface composition of the runway.
Value type:	SurfaceCompositionValues
Multiplicity:	1..*
Stereotypes:	
Attribute: runwaySlope	
Definition:	Measured slope of the runway.
Value type:	Measure
Multiplicity:	1..*
Stereotypes:	«voidable»
Attribute: runwaySlopeUom	
Definition:	Unit of measurement of the slope of the runway.
Value type:	UomSlopeValues
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: runwayStripLength	
Definition:	Length of the runway strip.
Value type:	Measure
Multiplicity:	1..*
Stereotypes:	«voidable»
Attribute: runwayStripLengthUom	
Definition:	Unit of measurement of the length of the runway strip.
Value type:	UomHorizontalValues
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: runwayStripWidth	
Definition:	Width of the runway strip.
Value type:	Measure
Multiplicity:	1..*
Stereotypes:	«voidable»
Attribute: runwayStripWidthUom	
Definition:	Unit of measurement of the width of the runway strip.
Value type:	UomHorizontalValues
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: runwayToda	
Definition:	Declared distance of the take-off distance available of a specific runway.
Value type:	Measure
Multiplicity:	1..*

Stereotypes:	«voidable»
Attribute: runwayTodaUom	
Definition:	Unit of measurement of the take-off distance available of a specific runway.
Value type:	UomHorizontalValues
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: runwayTora	
Definition:	Declared distance of the take-off run available of a specific runway.
Value type:	Measure
Multiplicity:	1..*
Stereotypes:	«voidable»
Attribute: runwayToraUom	
Definition:	Unit of measurement of the take-off run available of a specific runway.
Value type:	UomHorizontalValues
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: runwayAsda	
Definition:	Declared distance of the accelerate stop distance available of a specific runway.
Value type:	Measure
Multiplicity:	1..*
Stereotypes:	«voidable»
Attribute: runwayAsdaUom	
Definition:	Unit of measurement of the accelerate stop distance available of a specific runway.
Value type:	UomHorizontalValues
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: runwayLda	
Definition:	Declared distance of the landing distance available of a specific runway.
Value type:	Measure
Multiplicity:	1..*
Stereotypes:	«voidable»
Attribute: runwayLdaUom	
Definition:	Unit of measurement of the landing distance available of a specific runway.
Value type:	UomHorizontalValues
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: runwayVisualApproachSlopeIndicator	
Definition:	Information concerning the visual approach slope indicator system (e.g. PAPI, MEHT).

Value type:	CharacterString
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: runwayApproachLighting	
Definition:	Information concerning type, length, and intensity of runway approach lighting.
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: runwayThresholdLighting	
Definition:	Information concerning runway threshold lights, their colour, and wing bars.
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: runwayTouchdownZoneLighting	
Definition:	Information concerning type and length of the touchdown zone lighting.
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: runwayCentreLineLighting	
Definition:	Information concerning length, spacing, colour, and intensity of the runway centre line lights.
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: runwayEdgeLighting	
Definition:	Information concerning length, spacing, colour, and intensity of the runway edge lights.
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: runwayEndLighting	
Definition:	Information concerning length, spacing, colour, and intensity of the runway end lights and the wing bars.
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: runwayLightingRemarks	
Definition:	Information concerning other lighting at an aerodrome.
Value type:	CharacterString
Multiplicity:	1

Stereotypes:	«voidable»

Air Transport Network.RunwayThresholdPoint

Class: «featureType» Air Transport Network.RunwayThresholdPoint	
Definition:	The runway threshold point represents the coordinates where the take-off point and the touch-down of an aircraft are situated. This point serves as connection between the ground movement and the flight phase of an aircraft.
Subtype of:	AirSignificantPoint
Status:	Proposed
Stereotypes:	«featureType»
Attribute: aerodromeIcaoCode	
Definition:	ICAO code of the aerodrome.
Value type:	CharacterString
Multiplicity:	1
Stereotypes:	
Attribute: runwayDesignator	
Definition:	Name of the runway (e.g. 16L).
Value type:	CharacterString
Multiplicity:	1..*
Stereotypes:	
Attribute: runwayThresholdPointElevation	
Definition:	The vertical distance to the runway threshold of a runway measured from MSL.
Value type:	Measure
Multiplicity:	1
Stereotypes:	
Attribute: runwayThresholdPointElevation Uom	
Definition:	Unit of measurement of the vertical distance to the runway threshold of a runway measured from MSL.
Value type:	UomVerticalValues
Multiplicity:	1
Stereotypes:	

Air Transport Network.StopwayArea

Class: «featureType» Air Transport Network.StopwayArea	
Definition:	The stopway is 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 (ICAO, 1995b; 2004a).
Subtype of:	AerodromeArea

Status:	Proposed
Stereotypes:	«featureType»
Attribute: stopwaySurface	
Definition:	Surface composition of the stopway.
Value type:	SurfaceCompositionValues
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: stopwayLength	
Definition:	Length of the stopway.
Value type:	Measure
Multiplicity:	1..*
Stereotypes:	«voidable»
Attribute: stopwayLengthUom	
Definition:	Unit of measurement of the length of the stopway.
Value type:	UomHorizontalValues
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: stopwayWidth	
Definition:	Width of the stopway.
Value type:	Measure
Multiplicity:	1..*
Stereotypes:	«voidable»
Attribute: stopwayWidthUom	
Definition:	Unit of measurement of the width of the stopway.
Value type:	UomHorizontalValues
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: stopwaySlope	
Definition:	Measured slope of the stopway.
Value type:	Measure
Multiplicity:	1..*
Stereotypes:	«voidable»
Attribute: stopwaySlopeUom	
Definition:	Unit of measurement of the slope of the stopway.
Value type:	UomSlopeValues
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: stopwayLighting	
Definition:	Information concerning length and colour of stopway lighting.

Value type:	CharacterString
Multiplicity:	1
Stereotypes:	«voidable»

Air Transport Network.TaxiwayArea

Class: «featureType» Air Transport Network.TaxiwayArea	
Definition:	A taxiway is a defined path on a land aerodrome/heliport established for the taxiing of aircraft/helicopters and intended to provide a link between one part of the aerodrome and another, including aircraft/helicopter stand taxilanes, apron taxiways, rapid exit taxiways, and air taxiways (ICAO, 1995b; 2004a).
Subtype of:	AerodromeArea
Status:	Proposed
Stereotypes:	«featureType»
Attribute: taxiwayName	
Definition:	Name of the taxiway.
Value type:	CharacterString
Multiplicity:	1..*
Stereotypes:	
Attribute: taxiwaySurface	
Definition:	Surface composition of the taxiway.
Value type:	SurfaceCompositionValues
Multiplicity:	1..*
Stereotypes:	«voidable»
Attribute: taxiwayLength	
Definition:	Length of the taxiway.
Value type:	Measure
Multiplicity:	1..*
Stereotypes:	«voidable»
Attribute: taxiwayLengthUom	
Definition:	Unit of measurement of the length of the taxiway.
Value type:	UomHorizontalValues
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: taxiwayWidth	
Definition:	Width of the taxiway.
Value type:	Measure
Multiplicity:	1..*
Stereotypes:	«voidable»
Attribute: taxiwayWidthUom	

Definition:	Unit of measurement of the width of the taxiway.
Value type:	UomHorizontalValues
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: taxiwayStrength	
Definition:	Maximum weight of an aircraft allowed to move along the taxiway.
Value type:	CharacterString
Multiplicity:	1..*
Stereotypes:	«voidable»

A.2 Enumerations and code lists

Air Transport Network.AerodromeCategoryValues

Class: «enumeration» Air Transport Network.AerodromeCategoryValues	
Definition:	Aerodrome categories concerning the scope and importance of the ATS offered from and to it.
Status:	Proposed
Stereotypes:	«enumeration»
Value: DomesticNational	
Definition:	Aerodrome serving domestic national ATS or flights.
Code:	1
Value: DomesticRegional	
Definition:	Aerodrome serving domestic regional ATS or flights.
Code:	2
Value: International	
Definition:	Aerodrome serving international ATS or flights.
Code:	3

Air Transport Network.AerodromeTrafficScheduleValues

Class: «enumeration» Air Transport Network.AerodromeTrafficScheduleValues	
Definition:	Aerodrome categories concerning the kind of traffic offered from and to an aerodrome.
Status:	Proposed
Stereotypes:	«enumeration»
Value: Non-Scheduled	
Definition:	Non-scheduled flights may use the aerodrome.
Code:	1

Value: Private	
Definition:	Private flights may use the aerodrome.
Code:	2
Value: Scheduled	
Definition:	Scheduled flights may use the aerodrome.
Code:	3

Air Transport Network.AerodromeTrafficTypeValues

Class: «enumeration» Air Transport Network.AerodromeTrafficTypeValues	
Definition:	The traffic type indicates the technical equipment the aerodrome and the aircraft flying from and to it must have.
Status:	Proposed
Stereotypes:	«enumeration»
Value: IFR	
Definition:	The aerodrome and the aircraft flying from and to it must have must be equipped for IFR traffic.
Code:	1
Value: VFR	
Definition:	The aerodrome and the aircraft flying from and to it must have must be equipped for VFR traffic. An aerodrome may be equipped for VFR traffic only.
Code:	2

Air Transport Network.AerodromeTypeValues

Class: «codeList» Air Transport Network.AerodromeTypeValues	
Definition:	An aerodrome is 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 such as aeroplanes and helicopters.
Status:	Proposed
Stereotypes:	«codeList»
Value: AD_CIV	
Definition:	Aerodrome (with helicopter landing area) in civil use only.
Code:	1
Value: AD_JOINT	
Definition:	Aerodrome (with helicopter landing area) with joint civil and military operations.
Code:	2
Value: AD_MIL	
Definition:	Aerodrome (with helicopter landing area) in military use only.
Code:	3

Value: HP_CIV	
Definition:	Heliport or helicopter landing area in civil use only.
Code:	4
Value: HP_MIL	
Definition:	Heliport or helicopter landing area in military use only.
Code:	5

Air Transport Network.AirRouteClassValues

Class: «codeList» Air Transport Network.AirRouteClassValues	
Definition:	Air route classes or types are defined with respect to air navigation services.
Status:	Proposed
Stereotypes:	«codeList»
Value: EnrouteConventional	
Definition:	Air route which does not use area navigation (RNAV) for ATS.
Code:	1
Value: EnrouteNational	
Definition:	Air route which uses RNAV for ATS for national purpose (airlines) only.
Code:	2
Value: EnrouteRNAV	
Definition:	Air route which uses RNAV for ATS.
Code:	3
Value: InstrumentApproachProcedure	
Definition:	Air route in the form of an IAP, corresponding to the final approach and arrival during the landing phase of an aeroplane using IFR.
Code:	4
Value: StandardArrivalRoute	
Definition:	Air route in the form of a STAR, corresponding to the initial approach during the landing phase of an aeroplane using IFR.
Code:	5
Value: StandardInstrumentDeparture	
Definition:	Air route in the form of a SID, corresponding to the take-off phase of an aeroplane using IFR.
Code:	6
Value: VisualApproachProcedure	
Definition:	Air route in the form of a VAP, corresponding to the final approach and arrival during the landing phase using VFR if IFR fails.
Code:	7
Value: VisualFlightRules	
Definition:	Air route which uses VFR only, corresponding to the take-off phase, the final

	approach, and arrival during the landing.
Code:	8

Air Transport Network.AirRouteDirectionValues

Class: «enumeration» Air Transport Network.AirRouteDirectionValues	
Definition:	Determines the direction aircraft have to fly according to the semi-circular cruising levels. This split is indispensable for bi-directional air route segments.
Status:	Proposed
Stereotypes:	«enumeration»
Value: Even	
Definition:	Aircraft have to fly an even cruising direction according to the semi-circular cruising levels.
Code:	1
Value: Odd	
Definition:	Aircraft have to fly an odd cruising direction according to the semi-circular cruising levels.
Code:	2

Air Transport Network.AirRouteLevelValues

Class: «enumeration» Air Transport Network.AirRouteLevelValues	
Definition:	Determines whether an air route is situated in the lower or upper airspace of a State.
Status:	Proposed
Stereotypes:	«enumeration»
Value: Lower	
Definition:	The lower airspace extends from the surface of the earth to a specified upper limit that differs between the States (e.g. Austria: from ground up to FL245; Italy: from ground up to FL195).
Code:	1
Value: Upper	
Definition:	The upper airspace extends from the specified upper limit of the lower airspace - that differs between the States - to the top of the atmosphere (e.g. Austria: from FL245 to unlimited; Italy: from FL195 to unlimited).
Code:	2

Air Transport Network.AirspaceAreaClassValues

Class: «enumeration» Air Transport Network.AirspaceAreaClassValues	
Definition:	Each airspace is assigned to a specific airspace class in order to define the rules of the air. The airspace classes are defined in terms of flight rules and interactions

	between aircraft and ATC.
Status:	Proposed
Stereotypes:	«enumeration»
Value: ClassA	
Definition:	The airspace class A is referred to as controlled airspace. All operations must be operated under IFR or special visual flight rules (SVFR). All aircraft are subject to ATC clearance and are separated from each other by ATC. (ICAO, 2001b)
Code:	1
Value: ClassB	
Definition:	The airspace class B is referred to as controlled airspace. Operations may be operated under IFR, SVFR, or VFR. All aircraft are subject to ATC clearance and are separated from each other by ATC. (ICAO, 2001b)
Code:	2
Value: ClassC	
Definition:	The airspace class C is referred to as controlled airspace. Operations may be operated under IFR, SVFR, or VFR. All aircraft are subject to ATC clearance. Flights operating under IFR and SVFR are separated from each other and from aircraft operating under VFR. Additionally flights operating under VFR are given traffic information in regard to other VFR flights. (ICAO, 2001b)
Code:	3
Value: ClassD	
Definition:	The airspace class D is referred to as controlled airspace. Operations may be operated under IFR, SVFR, or VFR. All aircraft are subject to ATC clearance. Flights operating under IFR and SVFR are separated from each other, and are given traffic information in respect of VFR flights. Aircraft operating under VFR are given traffic information in regard to all other flights. (ICAO, 2001b)
Code:	4
Value: ClassE	
Definition:	The airspace class E is referred to as controlled airspace. Operations may be operated under IFR, SVFR, or VFR. Flights operating under IFR and SVFR are separated from each other, and are subject to ATC clearance. Flights under VFR are not subject to ATC clearance. Normally traffic information is given to all flights in regard to VFR flights. (ICAO, 2001b)
Code:	5
Value: ClassF	
Definition:	The airspace class F is referred to as uncontrolled airspace. Operations may be operated under IFR or VFR. ATC separation will be provided to aircraft operating under IFR if necessary. Traffic information may be given as far as is practical in regard to other flights. (ICAO, 2001b)
Code:	6
Value: ClassG	
Definition:	The airspace class G is referred to as uncontrolled airspace. Operations may be operated under IFR or VFR. ATC separation is not provided and traffic Information may be given in regard to other flights only if necessary. (ICAO,

	2001b)
Code:	7

Air Transport Network.AirspaceAreaOperatorValues

Class: «enumeration» Air Transport Network.AirspaceAreaOperatorValues	
Definition:	Defines whether an airspace is controlled by a civil or military ANSP.
Status:	Proposed
Stereotypes:	«enumeration»
Value: Civil	
Definition:	The airspace is controlled by a civil ANSP.
Code:	1
Value: Military	
Definition:	The airspace is controlled by a military ANSP.
Code:	2

Air Transport Network.AirspaceAreaTypeValues

Class: «codeList» Air Transport Network.AirspaceAreaTypeValues	
Definition:	According to the purpose and usage of airspace specific types with different characteristics are established. (Additionally is shown here that different countries have established different airspace types over their territory.)
Status:	Proposed
Stereotypes:	«codeList»
Value: ADIZ	
Definition:	An air defense identification zone (ADIZ) is an airspace within which the ready identification, the location, and the control of aircraft are required in the interest of national security. Typically, an aircraft entering an ADIZ is required to contact ATC and radio its planned course, destination, and any additional details. The airspace type ADIZ is used in Hungary or in Slovakia.
Code:	1
Value: ATZ	
Definition:	An aerodrome traffic zone (ATZ) is to provide protection to aircraft traffic in the critical stages of circuit, landing, and take-off of an aerodrome from the surface to a specified upper limit. ATZs are often established at military aerodromes. The airspace type ATZ is used in the Austria or in Czech Republic.
Code:	2
Value: AWY	
Definition:	An airway in terms of airspace is a control area or portion thereof in the form of a corridor.

	The airspace type AWY is used in the Italy.
Code:	3
Value: CLASS	
Definition:	The airspace type CLASS is a defined three-dimensional portion of the atmosphere having a specific class. The airspace structure in Germany uses CLASS airspace in large part.
Code:	4
Value: CTA	
Definition:	The control area (CTA) is a controlled airspace that exists in the vicinity of an airport. A CTA is often situated on top of a control zone (CTR) and provides protection to aircraft climbing out from the airport. CTAs are established in many European countries as framework for the entire airspace structure, e.g. Austria, Hungary, Switzerland.
Code:	5
Value: CTR	
Definition:	A CTR describes a volume of controlled airspace around an airport, which extends from the surface of the earth to a specified upper limit. CTRs are set up to protect air traffic operating to and from that airport. CTRs are defined in many European countries around high traffic airports (e.g. Austria, Germany, Slovenia).
Code:	6
Value: DangerArea	
Definition:	An airspace within which (military) activities dangerous to the flight of aircraft may exist (at specified times). Danger areas are defined in many countries due to military activities (e.g. Austria, Germany, Italy, Switzerland) or environmental reasons (e.g. bird migration).
Code:	7
Value: FIR	
Definition:	The airspace in which an ANSP provides information, management, and search-and-rescue services for those flights it is aware of. FIRs are often identical to the State boundary (e.g. Austria, Hungary, Slovenia). Smaller countries that provide no air navigation service are supported by other ANSPs (e.g. Switzerland controls the airspace of Liechtenstein).
Code:	8
Value: GLD	
Definition:	A glider area is usually established where thermic or topographic conditions support glider activities (e.g. Austria, Germany, Switzerland).
Code:	9
Value: HLG	
Definition:	A high level glider area is usually established where thermic or topographic conditions support high level glider activities (e.g. Austria in the alpine area).
Code:	10

Value: HPG	
Definition:	A hang and para glider area is usually established where thermic conditions due to topographic factors support hang and para glider activities (e.g. Austria and Switzerland in the alpine area).
Code:	11
Value: MIL	
Definition:	Military training and exercise areas are established where the armed forces are performing specific flight activities dangerous to other aircraft at specified times. Hungary and Italy have already defined this airspace type, Austria is planning to install this airspace type.
Code:	12
Value: OCA	
Definition:	The oceanic control area (OCA) is a controlled airspace that exists on top of territorial waters. OCAs are established in some European countries with access to the ocean.
Code:	13
Value: ProhibitedArea	
Definition:	An airspace within which activities dangerous to the flight of aircraft exist (at specified times) and the flight of aircraft is prohibited. Prohibited areas are defined for instance around nuclear plants in the Czech Republic.
Code:	14
Value: RestrictedArea	
Definition:	An airspace within which activities dangerous to the flight of aircraft exist (at specified times) and the flight of aircraft is restricted in accordance with certain specified conditions. Restricted areas are defined in many countries due to military activities or environmental reasons (e.g. Austria, Germany, Italy, Switzerland).
Code:	15
Value: RAS	
Definition:	Regulated airspaces of local special character not otherwise covered are summed up in the airspace type RAS. Hungary and Slovakia use this airspace type.
Code:	16
Value: SECTOR	
Definition:	Control sectors that need special monitoring due to heavy traffic are (e.g.) defined by the Slovakian State.
Code:	17
Value: SRA	
Definition:	Special rules areas (SRA) are an Austrian special form of a controlled airspace and are used in the vicinity of all international airports.
Code:	18

Value: TMA	
Definition:	A TMA is usually established at the confluence of ATS routes in the vicinity of one or more major (military) aerodromes. TMAs are established in many countries as part of the main airspace framework around international airports, e.g. Austria, Hungary, Switzerland.
Code:	19
Value: TMZ	
Definition:	A transponder mandatory zone (TMZ) is established around major aerodromes where uncontrolled airspace may cause problems between IFR flights and uncontrolled VFR traffic. TMZs are established in Austria, Germany.
Code:	20
Value: TRA	
Definition:	A temporary reserved area (TRA) is an airspace temporarily reserved and allocated for the specific use of a particular (military) user during a determined period of time and through which other traffic may be allowed to transit under ATC clearance. TRAs are one part of the flexible airspace structures EUROCONTROL has installed and are already established in the Czech Republic.
Code:	21
Value: TSA	
Definition:	An airspace temporarily segregated and allocated for the exclusive use of a particular (military) user during a determined period of time and through which other traffic will not be allowed to transit. Temporary segregated areas (TSA) are established in the Czech Republic and are one part of the flexible airspace structures EUROCONTROL has installed.
Code:	22
Value: UIR	
Definition:	If an horizontal division of the FIR exists the upper part is called upper information region (UIR). UIRs are established in Slovenia or Italy.
Code:	23

Air Transport Network.DesignatedPointElevationUsageValues

Class: «enumeration» Air Transport Network.DesignatedPointElevationUsageValues	
Definition:	Indicates the altitude or flight level an aircraft has to retain at a designated point due to ATC or obstacle clearance.
Status:	Proposed
Stereotypes:	«enumeration»
Value: AtOrAbove	
Definition:	An aircraft has to retain at or above a designated altitude or flight level.

Code:	1
Value: AtOrBelow	
Definition:	An aircraft has to retain at or below a designated altitude or flight level.
Code:	2
Value: Mandatory	
Definition:	An aircraft has to retain at a designated altitude exactly or flight level.
Code:	3

Air Transport Network.DesignatedPointFunctionValues

Class: «codeList» Air Transport Network.DesignatedPointFunctionValues	
Definition:	Indicates whether a designated point has a special function during starting or langing phase of a flight.
Status:	Proposed
Stereotypes:	«codeList»
Value: FinalApproachFix	
Definition:	The final approach fix is the point where the final approach begins in an instrument approach.
Code:	1
Value: Holding	
Definition:	This designated point serves as access to a holding where obstacle clearance is ensured.
Code:	2
Value: InitialApproachFix	
Definition:	The initial approach fix is the point where the initial approach segment of an instrument approach begins.
Code:	3
Value: MissedApproachPoint	
Definition:	This designated point serves as indicator whether an aircraft fulfils the parameters (e.g. speed, descent gradient) to land the aircraft. If these parameter are not met the aircraft is not allowed to land and has to try a second time.
Code:	4

Air Transport Network.DesignatedPointReportingTypeValues

Class: «enumeration» Air Transport Network.DesignatedPointReportingTypeValues	
Definition:	A code indicating the type of position report of an aircraft required by an ATC unit for the start point of a route segment.
Status:	Proposed
Stereotypes:	«enumeration»
Value: Compulsory	

Definition:	The aircraft has to report the arrival at this waypoint.
Code:	1
Value: OnRequest	
Definition:	The aircraft has to report the arrival at this waypoint on request of ATC only. Primarily this type of reporting point serves as orientation aid for the pilot or is necessary for a procedure.
Code:	2

Air Transport Network.DesignatedPointTypeValues

Class: «enumeration» Air Transport Network.DesignatedPointTypeValues	
Definition:	Aviation procedures make use of both fly-by and fly-over waypoints.
Status:	Proposed
Stereotypes:	«enumeration»
Value: FlyBy	
Definition:	A fly-by waypoint is a waypoint that marks the intersection of two straight flight paths. The transition from one path to another is made by the aircraft using a precisely calculated turn that “flies by” but the aircraft does not vertically cross the waypoint.
Code:	1
Value: FlyOver	
Definition:	A fly-over waypoint is a waypoint that must be crossed vertically by an aircraft.
Code:	2

Air Transport Network.InfrastructureAtsServiceValues

Class: «codeList» Air Transport Network.InfrastructureAtsServiceValues	
Definition:	A code specifying the type of service represented by ATC. One service can be done via different frequencies especially on major aerodromes.
Status:	Proposed
Stereotypes:	«codeList»
Value: APP	
Definition:	Approach control service is given for both arrival and departure.
Code:	1
Value: ATIS	
Definition:	Automated terminal information service is given.
Code:	2
Value: DEL	
Definition:	The delivery service gives routing clearances for departing flights.
Code:	3
Value: GND	

Definition:	ATS for ground movement and taxiing is given.
Code:	4
Value: TFI	
Definition:	Terminal flight information for VFR flights in the lower airspace within the TMA of an aerodrome is given.
Code:	5
Value: TWR	
Definition:	The main frequency for ATC of an airport is assigned to the aerodrome control tower.
Code:	6

Air Transport Network.NavaidClassValues

Class: «codeList» Air Transport Network.NavaidClassValues	
Definition:	A navigational aid or navaid is any sort of marker which aids the pilot or an FMS in navigation during the entire flight.
Status:	Proposed
Stereotypes:	«codeList»
Value: DME	
Definition:	Distance measuring equipment (DME) is a transponder-based radio navigation technology measuring distances by timing the propagation delay of radio signals.
Code:	1
Value: ILS	
Definition:	The instrument landing system (ILS) is a ground-based instrument approach system that provides precision guidance to an aircraft approaching a runway, using a combination of radio signals and high-intensity lighting arrays to enable a safe landing.
Code:	2
Value: Locator	
Definition:	A locator is a low powered non-directional beacon (NDB) used for final approach only.
Code:	3
Value: NDB	
Definition:	An NDB is a radio transmitter at a known location, used as an (en-route) navaid. The signal transmitted does not include inherent directional information.
Code:	4
Value: TACAN	
Definition:	A TACAN (TACtical Air Navigation) is a navigation system used by military aircraft and provides distance and bearing from a ground station.
Code:	5
Value: VDF	

Definition:	A VDF provides directional assistance to VFR aircraft which includes provision of homing, fix, track-out, time, distance, and ground speed estimates.
Code:	6
Value: VOR	
Definition:	A VOR (VHF Omni-directional Radio Range) ground station broadcasts a VHF (very high frequency) radio composite signal including the station's identifier in morse code and data that allows the airborne receiving equipment to derive a magnetic bearing from the station to the aircraft.
Code:	7
Value: VORDME	
Definition:	A VOR/DME is a collocated navaid of VOR and DME supporting the advantages of both navaids in order to support the aircraft with more detailed information.
Code:	8
Value: VORTAC	
Definition:	A VOR/DME is a collocated navaid of VOR and TACAN used by military aircraft supporting the advantages of both navaids in order to support the aircraft with more detailed information.
Code:	9

Air Transport Network.ObstaclePointIdentificationValues

Class: «enumeration» Air Transport Network.ObstaclePointIdentificationValues	
Definition:	The identification of an obstacle by lighting or day marking supports the pilot during the flight.
Status:	Proposed
Stereotypes:	«enumeration»
Value: Lighting	
Definition:	A code indicating that an obstacle is lighted.
Code:	1
Value: Marking	
Definition:	A code indicating that an obstacle is day marked.
Code:	2

Air Transport Network.SurfaceCompositionValues

Class: «codeList» Air Transport Network.SurfaceCompositionValues	
Definition:	Surface material of the aerodrome area.
Status:	Proposed
Stereotypes:	«codeList»
Value: Aluminium	
Definition:	Surface material made of an aluminium layer or framework usually used for

	heliports (at hospitals).
Code:	1
Value: Asphalt	
Definition:	Surface material made of an asphalt layer.
Code:	2
Value: Bitumen	
Definition:	Surface material made of a bitumen layer.
Code:	3
Value: Concrete	
Definition:	Surface material made of a concrete layer.
Code:	4
Value: Grass	
Definition:	Surface consisting of a grass layer.
Code:	5
Value: Ice	
Definition:	Surface consisting of an ice layer (occurrences exclusively in the northern parts of Europe).
Code:	6
Value: Water	
Definition:	Surface consisting of a water layer (e.g. lake or sea).
Code:	7

Air Transport Network.UomFrequencyValues

Class: «enumeration» Air Transport Network.UomFrequencyValues	
Definition:	Frequencies used in air navigation are deployed in different units. Frequency is defined as a number of cycles, or periods, per unit time. 1 Hz means that an event is repeated once per second.
Status:	Proposed
Stereotypes:	«enumeration»
Value: KHZ	
Definition:	The frequency value uses the unit of measurement kilohertz.
Code:	1
Value: MHZ	
Definition:	The frequency value uses the unit of measurement megahertz.
Code:	2
Value: GHZ	
Definition:	The frequency value uses the unit of measurement gigahertz.
Code:	3

Air Transport Network.UomHorizontalValues

Class: «enumeration» Air Transport Network.UomHorizontalValues	
Definition:	Specified horizontal units of measurement to be valid in air and ground operations in international air navigation.
Status:	Proposed
Stereotypes:	«enumeration»
Value: FT	
Definition:	One foot is a non-SI unit and equals the length to 0.3048 metre exactly.
Code:	1
Value: M	
Definition:	The metre is a unit of length. It is the basic unit of length in the metric system and in the SI.
Code:	2
Value: NM	
Definition:	A nautical mile is a non-SI unit and equals the length to 1852 metres exactly.
Code:	3

Air Transport Network.UomSlopeValues

Class: «enumeration» Air Transport Network.UomSlopeValues	
Definition:	Specified units of measurement for angles to be valid in air and ground operations in international air navigation.
Status:	Proposed
Stereotypes:	«enumeration»
Value: Degree	
Definition:	The unit degree indicates an angle as an angle of inclination from the horizontal of a right triangle.
Code:	1
Value: Percentage	
Definition:	Percentage correlates height and distance to gain the slope angle. The grade is the most commonly used unit for stating slope in transportation.
Code:	2

Air Transport Network.UomSpeedValues

Class: «enumeration» Air Transport Network.UomSpeedValues	
Definition:	Specified units of measurement for speed to be valid in air and ground operations in international air navigation.
Status:	Proposed
Stereotypes:	«enumeration»

Value: KM_H	
Definition:	The unit km/h is an SI unit and describes the speed equal to 1 kilometre per hour.
Code:	1
Value: KT	
Definition:	A knot is a non-SI unit and describes the speed equal to 1 nautical mile per hour.
Code:	2

Air Transport Network.UomVerticalValues

Class: «enumeration» Air Transport Network.UomVerticalValues	
Definition:	Specified vertical units of measurement to be valid in air and ground operations in international air navigation.
Status:	Proposed
Stereotypes:	«enumeration»
Value: FL	
Definition:	The term flight level (FL) is defined as a surface in the atmosphere of constant atmospheric pressure which is related to a specific pressure datum and is separated from other such surfaces by specific pressure intervals (ICAO, 2001a). This entity is used by civil and military airspaces users in big heights.
Code:	1
Value: FT	
Definition:	One foot is a non-SI unit and equals the length to 0.3048 metre exactly. This entity is used by civil and military airspaces users in lower heights.
Code:	2
Value: M	
Definition:	The metre is a unit of length, the basic unit of length in the metric system and in the SI. This entity is used by glider aircraft all over the world as well as in Russia or China.
Code:	3

Air Transport Network.WorkingHoursTypeValues

Class: «enumeration» Air Transport Network.WorkingHoursTypeValues	
Definition:	A code indicating the working hours of a feature or service (e.g. airspace, navaid, aerodrome).
Status:	Proposed
Stereotypes:	«enumeration»
Value: H24	
Definition:	The activity period of the feature or service is day and night (twenty-four seven).
Code:	1
Value: HJ	

Definition:	The activity period of the feature or service lasts from sunrise to sunset.
Code:	2
Value: HN	
Definition:	The activity period of the feature or service lasts from sunset to sunrise.
Code:	3
Value: HO	
Definition:	The activity period of the feature or service meets operator requests.
Code:	4
Value: HX	
Definition:	The activity period of the feature or service has no specific working hours.
Code:	5
Value: NOTAM	
Definition:	The activity periods of the feature or service are published by NOTAM.
Code:	6
Value: TIMSH	
Definition:	The activity periods of the feature or service are specified in a related timesheet.
Code:	7